Honeywell

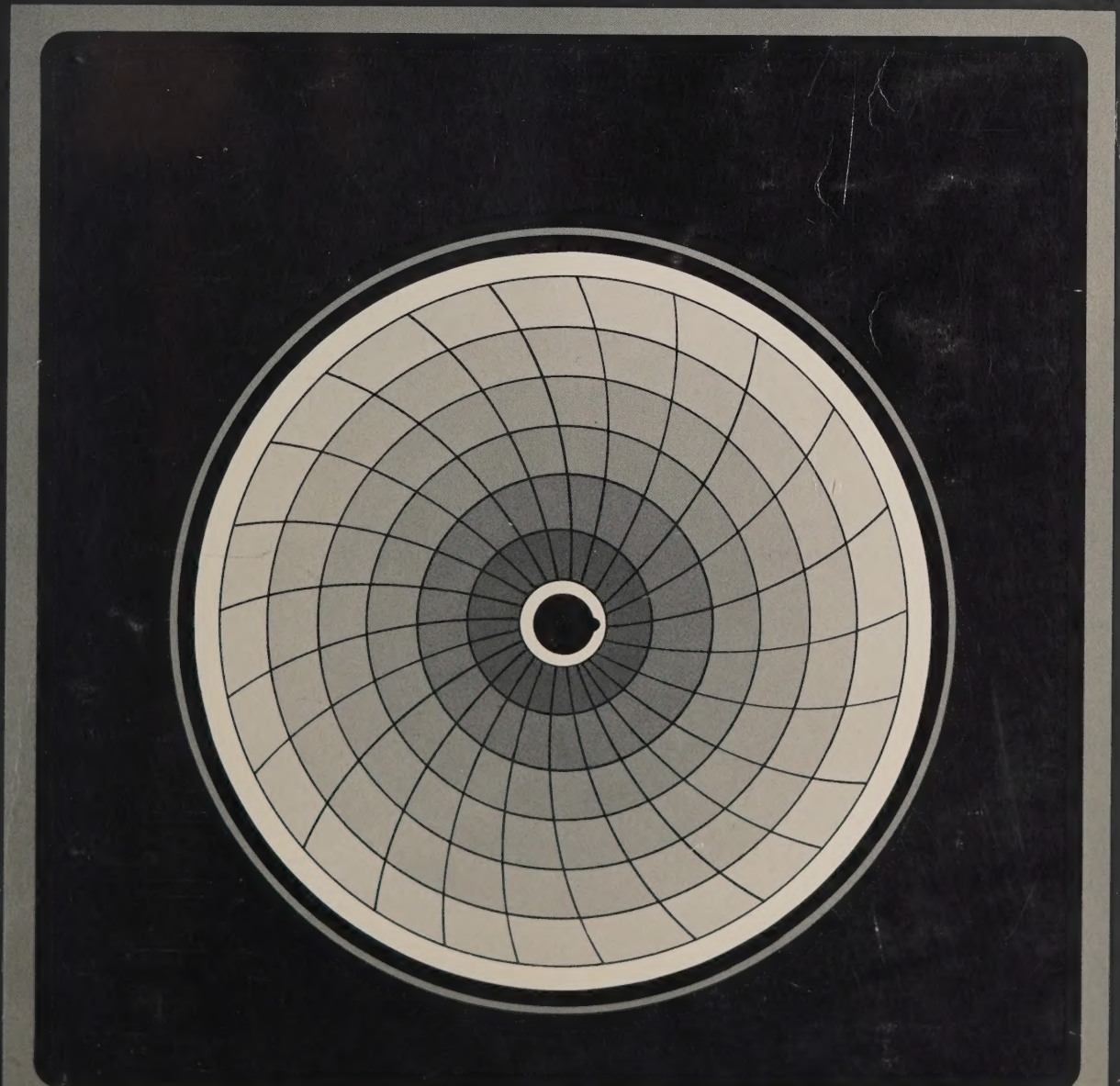
44-01-25-01

Recorders, Indicators and Controllers

Series AR 100

Recorder-Controller, Limit Controller and Cam Programmer

Product Manual



ERRATA SHEET 6/24/81

AR100 PRODUCT MANUAL #44-01-25-01 (4/81)

SECTION 44-01-13-01, page 3; range 0° to 600°F, Pt 100
R4 as listed = P/N 24001652-194 (14.9K)
should be = P/N 24001652-149 (14.9K)

SECTION 44-01-44-01, page 5; range 0° to 600°F Pt 100
R4 as listed = P/N 24001652-194 (19.4K)
should be = P/N 24001652-149 (14.9K)

SECTION 44-01-13-01, page 5; Slidewire Transducer, 1000 ohm
SA Connector Components as listed = P/N 2420092-001
P/N 2420092-004
should be = P/N 2420092-001
P/N 2420092-009

SECTION 44-01-14-01, page 4; Table 1 - Printed Wiring Board Assemblies
replace with the attached Tables 1A and 1B
see page 2 of Errata Sheet

ERRATA SHEET 6/24/81 (CONT'D.)

SECTION 44-01-14-01, Table 1A - Printing Wiring Board Assemblies
All AR100 Models except AR5XX (Cam Programmer)
with M.S.G. Table V Selection _ 2 or _ 3.

TYPE	100V AC	120V AC	230V AC
Record only	24110262-025	24110262-001	24110262-002
& Alarm	-026	-003	-004
Rec. w/ON/OFF	-027	-005	-006
& Alarm	-028	-007	-008
Rec. w/1M Time Prop.	-029	-009	-010
& Alarm	-030	-011	-012
Rec. w/1M Current Prop.	-031	-013	-014
& Alarm	-032	-015	-016
Rec. w/Man. Reset Limit	24110308-003	24110308-001	24110308-002
Rec. w/3M Time Prop.	24110313-017	24110313-001	24110313-002
& Alarm	-018	-003	-004
Rec. w/3M Current Prop.	-019	-005	-006
& Alarm	-020	-007	-008

TABLE 1B - PRINTED WIRING BOARD ASSEMBLIES
ONLY FOR AR5XX (Cam Programmer) with M.S.G.
TABLE V Selection _ 2 or _ 3.

Program S.P. Only	24110300-025	24110300-001	24110300-002
& Alarm	-026	-003	-004
Prog. w/ON/Off	-027	-005	-006
& Alarm	-028	-007	-008
Prog. w/1M Time. Prop.	-029	-009	-010
& Alarm	-030	-011	-012
Prog. w/1M Current Prop.	-031	-013	-014
& Alarm	-032	-015	-016
Prog. w/3M Time Prop.	24110313-021	24110313-009	24110313-010
& Alarm	-022	-011	-012
Prog. w/3M Current Prop.	-023	-013	-014
& Alarm	-024	-015	-016

Series AR 100
Recorder-Controller and Cam Programmer

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WARRANTY

The Company warrants all components to be free from defects in workmanship and material under normal use and service. Equipment returned transportation prepaid to the Company's originating factory within 12 months from the date of the code stamped on the device and found by the Company's inspection to be defective in workmanship or material will be repaired or replaced, at the Company's option, free of charge and returned prepaid. Relays and lamps shall not be covered by warranty if they fall by reason of wear or burnout through usage. *With exception of the 12 month warranty, set forth above, the Company makes no express warranties, no warranty of merchantibility and no warranties which extend beyond the description on the face hereof.* In no event will the Company be liable for indirect, special, or consequential damages of any nature whatsoever.

Process Control Division, 1100 Virginia Drive, Fort Washington, PA 19034

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Honeywell

Series AR 100 Recorder-Controller

Specification

Function

Honeywell's series AR 100 recorder-controller instruments are designed for reliable operation, accurate measurement, and precise recording and controlling of any process variable that can be translated into a voltage or resistance signal in industrial processes.

Two basic models are available: single-pen (Figure 1) and two-pen (Figure 2). Both models can be equipped with independent control forms and alarm functions for the control of industrial processes and machinery. An optically activated event switch is also available on single-pen models.

Integral cam programmed set point models are available for single-pen recorders with independent control forms and alarm functions as well as. auxiliary cam functions. See Specification 53-01-03-01.

The AR 100 recorder-controller is ideally suited for applications involving the recording and controlling of environmental chambers, food processing machines, furnaces and ovens, and packaging machinery.

Honeywell offers a full line of sensors and transmitters that produce a compatible range of dc voltage or current signals which can be used as input to the AR 100 recorder-controller. These devices measure:

- Temperature (thermocouple or RTD)
- Pressure
- Flow
- Liquid Level

(4 to 20 mA or 1 to 5 Vdc process transmitter)

- Humidity (gold grid sensor)

Description

Enclosure

AR 100 recorder-controller is enclosed in a case that is designed for surface or panel mounting.

The case is of durable foamed Noryl* resin construction with a gasketed, glass windowed door. Knockouts for wiring are provided in the bottom and sides of the case. All cases have knockouts and mounting hardware.

*Registered Trademark

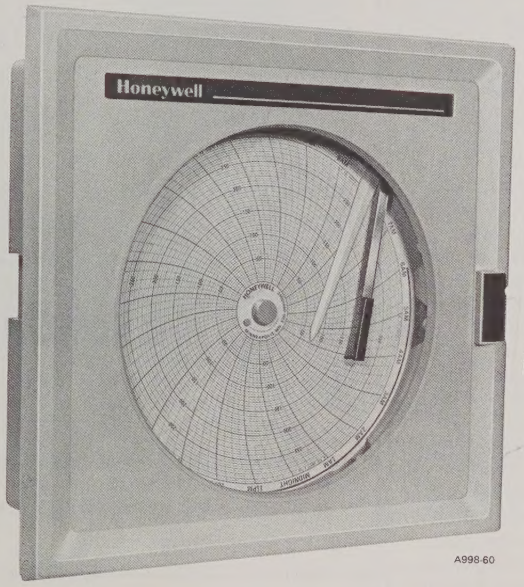


Figure 1 – Single-Pen Unit

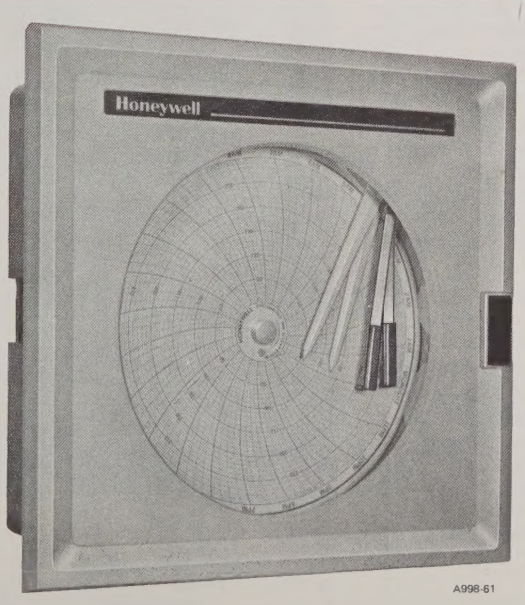


Figure 2 – Two-Pen Unit

Components

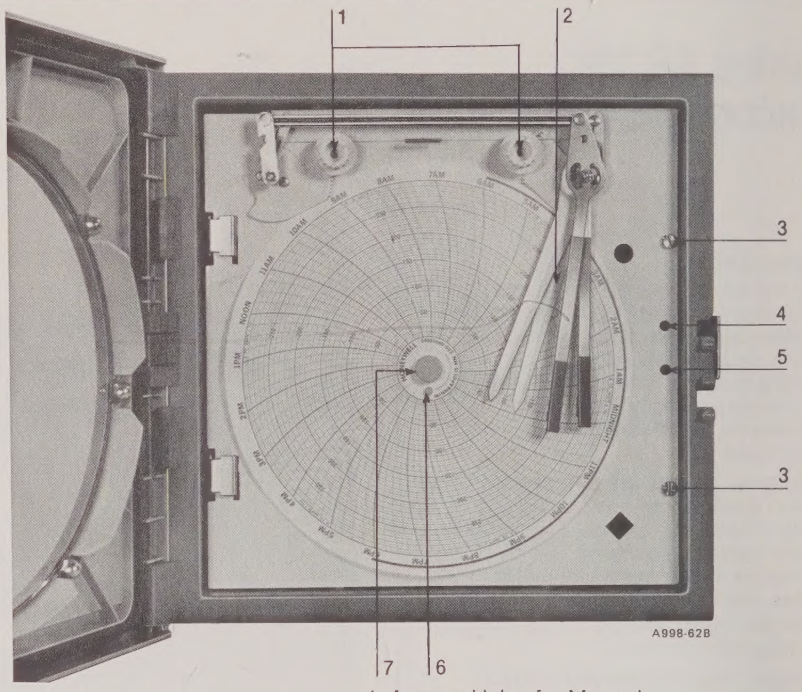
With the door open (Figure 3), the hinged chart plate swings out 90 degrees for convenient component access (Figure 4). The display components, as well as some parts of the instruments servo balance system, are located on the chart plate. Display components include the 10-inch diameter chart, chart drive assembly, disposable fiber-tip pen cartridge, and index setting mechanism (on controller models only). The chart plate has an access hole for each manual reset adjustment on proportional controllers, a manual reset switch (and a signal light) for each limit controller, and a time index mark for chart time alignment. Synchronous chart drive motors provide two different chart speeds. Tapered hub and locating pin on the chart drive assembly assure correct alignment when chart is renewed. Assembly has a clutch for initial time alignment, or resetting in case of power interruption. Pen arm carries disposable fiber-tip, snap-on pen cartridge.

The servo balance system consists of solid state circuitry located on the main printed circuit board mounted in the rear of the case, and a servo assembly mounted on the back of the chart plate. The servo balance system converts electrical signals from process variable sensors into precise mechanical positions. Basically, this system measures an unknown emf or potential by balancing the unknown emf against a known or calibrated emf established by the position of a contactor on a slidewire.

Solid state circuitry integrates power supply, measuring circuit, preamplifier and pen positioning servo functions. Plug-in range resistors make field range changes possible. The servo assembly includes an ac servo motor and a precision wound rebalancing slidewire; it also includes a set point wiper on models with a control form. Servo motor directly drives the wiper and the pen arm for accurate input signal tracking and reliable pen motion.

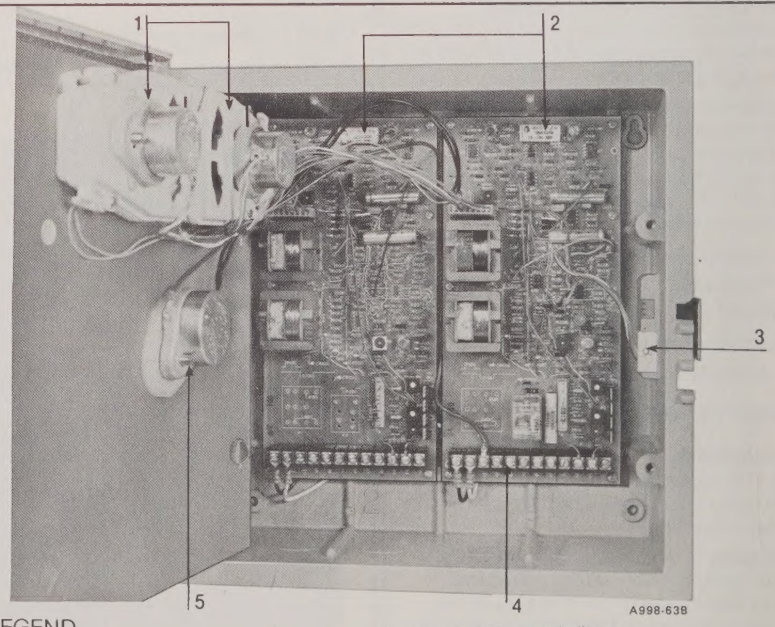
Field wiring connects to the screw terminals on the barrier connector strip at the bottom of the printed circuit board.

Two-pen models have two independent servo balance systems with or without independent control forms. See Control Selections for control form description. The separate ac servo motors drive their respective pens through a common pivot point with mechanical linkages. Color coded pens make traces easy to identify.



LEGEND
1. Control Index Knobs
2. Control index Pointers
3. Chart Plate Latching Screws
4. Access Holes for Manual Reset Adjustments
5. Disposable Fiber-Tip Pen Cartridges – Red and Purple
6. Chart Locating Pin
7. Tapered Hub

Figure 3 – Door Open



LEGEND
1. Servo Assemblies – No. 1 and No. 2 Pens
2. Typical main Printed Circuit Boards
3. Manual Reset Adjustment – Proportional Control
4. Screw Terminals for Field Wiring
5. Chart Drive Assembly

Figure 4 – Chart Plate Open

Control Selections

Control form output signals activate remote final control devices (valves, motors, relays, SCR's, etc.) to keep the process at the desired set point. Six types of control forms are offered:

- Two position switching (on/off, high/low)
- One mode time proportioning (with manual reset/offset adjust)
- Three mode time proportioning (with auto-reset/offset adjust)
- One mode current proportioning (with manual reset/offset adjust)
- Three mode current proportioning (with auto-reset/offset adjust)
- High or low limit with manual reset

Solid state control circuitry is located on the main printed circuit board with the recording servo balance system circuitry and optional alarm circuitry, but each is an independent parallel function. This "thru control" concept assures optimal control sensitivity and speed of response, independent of the recording servo system response.

On/Off or High/Low control action is used in general control applications, usually with slow-changing processes. Typical control elements include triacs, SCR's, relays, contactors, solenoid valves, and two-position (ModuTrol) motors.

Control action opens or closes a relay depending on the value of the process variable relative to the set point (above or below).

Time Proportioning control action is useful in application to heating/cooling, moisture controls, or control plus alarm functions. Typical control elements include triacs, SCR's, relays, and contactors.

Control action cycles a relay on and off in proportion to the difference between the process variable input and the set point. Single mode control (proportional band only) is used for processes with little or no load change. Three mode control (proportional band, rate, and auto-reset) is used for processes with frequent load changes.

Current Proportioning control action is especially useful in applications using SCR power packs, saturable core reactors, proportioning ModuTrol motors, current to pneumatic (I/P) transducers for control of pneumatically operated devices, or control plus alarm functions.

Control action supplies a direct current output (to a final control element) in proportion to the difference between the process variable input and the set point.

Limit control is designed for high or low limit cutoff control function. It immediately shuts down the process, when the process variable reaches a preset critical point. Manual resetting is required after any shutdown, safety shutoff, or power interruption as well as on initial start-up. Automatic reset on startup and after power interuption is available as an optional kit.

A self-checking circuit cycles sixty times a second and shuts down the process on most major component failures. A SPDT electromechanical relay is used for output switching action, and a red signal light, visible through the chart, indicates when the relay is de-energized. The manual reset switch is accessible with the case door open. Remote reset is available as an optional feature.

Limit controllers are ideally suited for applications requiring a preselected alarm or control override.

- High Limit
  Relay energized and red light off, when process variable is below set point; and de-energized and on, when above set point. Upscale thermocouple burnout is standard.
- Low Limit*
  Relay energized and red light off, when process variable is above set point; and de-energized and on when below set point. Upscale thermocouple burnout can be converted to downscale.

*Requires change of plug-in jumpers on the printed circuit board.

Specifications

Operating Conditions

	Reference Conditions	Rated Conditions	Extreme Conditions	Transportation and Storage
Ambient Temperature Range	67 to 77°F 19 to 25°C	40 to 120°F 4.5 to 49°C	30 to 140°F −1 to 60°C	−40 to 151°F −40 to 66°C
Relative Humidity (% RH)	10 to 55	5 to 90*	5 to 95*	5 to 98
Vibration				
Frequency (cps)	0	0.05 to 60	0.05 to 200	
Acceleration (g)	0	0.2	0.5	
Mechanical Shock				
Acceleration (g)	0	0.5	30	
Duration (ms)	0	30	30	
Mounting Position from Vertical				
Tilted Forward	5°	30°	45°	any
Tilted Backward	5°	30°	90°	any
Tilted to Side (±)	5°	10°	20°	any
Power Requirements Vac @:				
50 Hz	240 (or 100)	210 to 245 (95 to 105)	196 to 253 (90 to 110)	
60 Hz	120 (or 100)	110 to 125 (95 to 105)	107 to 127 (90 to 110)	

*Absolute humidity limit of 400 grains H_2O/lb dry air.

Performance

Recorder:

Accuracy	±1.0 percent of span
Reproducibility	0.5 percent of span
Deadband	0.5 percent of span maximum
Span Step Response Time	10 seconds maximum; 9 seconds minimum (60 Hz)

Specifications (continued)

Inputs:	
Thermocouple	*Types:* E, J, K, R, S, and T. *Spans:* 8.5 mV minimum, 55 mV maximum. *Maximum Source Resistance:* 500 ohms @ rated conditions; 2500 ohms @ extreme conditions.
Resistance Temperature Detector (RTD)	*Type:* Platinum two- or three-wire (100Ω @ 0°C; and 139.02Ω @ 100°C), or (200Ω @ 0°C; and 278.04Ω @ 100°C), or (500Ω @ 0°C; and 695.1Ω @ 100°C) *Span:* 20 ohms minimum. Leadwire resistance compensation is provided for three-wire sensors having equal resistance in the three leads. Compensation reduces leadwire resistance effect by a factor of at least seven.
Differential RTD (Wet/Dry Bulb)	*Type:* Platinum (100Ω @ 0°C; and 139.02Ω @ 100°C), or (200Ω @ 0°C; and 278.04Ω @ 100°C), or (500Ω @ 0°C; and 695.1Ω @ 100°C) Two, 2-wire sensors combined to form 3-wire unit. *Span:* 12.5 ohms minimum.
Current (mA dc)	*Range:* 4 to 20 mA. *Input resistance:* 2.5 ohms.
Voltage (Vdc, mV dc)	*Ranges:* 0 to 5 Vdc, 1 to 5 Vdc, and 0 to 10 mV dc. *Input Impedance:* 0.8 Megohms minimum.
Relative Humidity	*Type:* Composite gold grid sensor. *Range:* 5% to 98% RH (used with a 0 to 100% chart).
Controller and Alarm Outputs:	
Relay (electromechanical spdt) (For On/Off, High/Low switching, Time Proportioning or limit control forms, Event switching function*, or Alarm function)	*Control Relay Contact Ratings:* Resistive load: 5 A @ 120/240 Vac. Pilot duty: 50 VA @ 120/240 Vac. *Event Relay/Alarm Relay Contact Ratings:* Resistive load: 2 A @ 120/240 Vac. Pilot duty: 50 VA @ 120/240 Vac. Alarm at high condition is standard. Low alarm requires field change of plug-in jumpers on circuit board.
Current (For Current Proportioning control form)	*4 to 20 mA dc:* 0 to 600-ohm load. Reverse action (output decreases with increasing input) is standard. Direct action requires field change of plug-in jumpers on circuit board.
Voltage, PV output (3-mode controller only)	*0 to 5 Vdc:* Maximum current: 5 mA dc Minimum load: 1000Ω
Other:	
Interference (Stray) Rejection	*Normal Mode:* 50 or 60 Hz: 20 times span. *Common Mode:* 50 or 60 Hz: 30 volts. Dc: 42 volts. *Magnetic Fields:* 0.5 oersted. (approximately 39.8 amperes/meter)
Power Consumption	*Controller:* 12 Watts, maximum (with optional event switching function, 16 watts maximum) *Two Pen:* 20 Watts, maximum. *Chart Illumination Kit:* 2 Watts.
Thermocouple Burnout Effects	Sensor break protection drives pens upscale as standard. Field change of electrical jumper wires allows downscale response.(Factory calibrated to simulate a 10Ω thermocouple loop resistance.)
Design	
Pens	Disposable fiber-tip pen cartridges on stainless steel pen arms.
Circular Chart	10.34 inches (260 mm) diameter; 4 inches (100 mm) calibrated width.
Chart Speeds	24 hours/revolution (15 min./div.) or 7 days/revolution (2 hrs./div.)

*(Special option, for single pen models only. Consult Fort Washington.)

Specifications (continued)

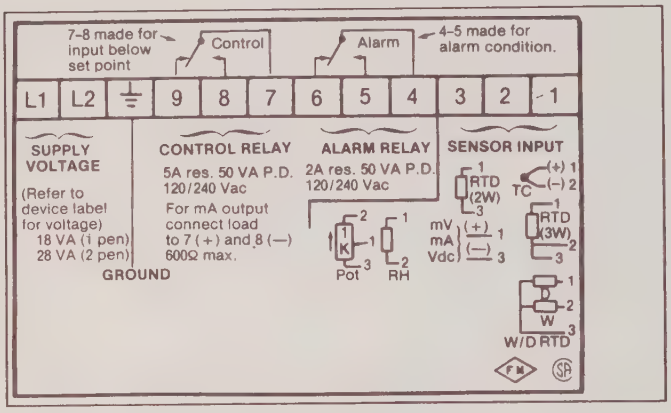
No. of Input Channels (Pens)	One or two continuous inputs. Single pen (red), or two-pen (red and purple).
Chart Plate	Opens to beyond 90 degrees for access to printed circuit board and wiring terminals; removable.
Case	Gray foamed Noryl* resin; 1/2-inch conduit knockouts for field wiring in bottom and right and left sides.
Door	Beige Noryl* resin; glass window for chart viewing; opens to 105 degrees; gasketed; latched.
Rebalancing Element (Measuring Slidewire)	Precision wirewound slidewire with precious metal contactor serves both the pen positioning servo and the electric control set point reference for the frontset control indices.
Control	Index pointers indicate control set point; beige plastic, #2 pen index marked with pen color (purple) on tip. Each pen may have one of the following single mode control forms: Two-Position (On/Off, High/Low) switching, Time Proportioning, or Current Proportioning control.

Adjustments

Non Control	Two-Position	Time Proportion	Current Proportion	Limit		
•	•	•	•	•	**Span and Zero Calibration**	Potentiometers accessible on controller printed circuit board.
•	•	•	•		**Low Alarm Mode**	Printed circuit board jumper wire change from standard high-value alarm mode.
•	•	•	•	•	**Downscale Thermocouple Burnout**	Printed circuit jumper wire change from standard upscale sensor break response.
•	•	•	•		**Alarm Set Point**	Potentiometer accessible on controller printed circuit board.
	•	•	•	•	**Control Set Point**	Index knob and pointer accessible on front of chart plate.
		•	•		**Manual Reset (offset)**	Potentiometer allows readjustment of offset within the proportional band.
		•	•		**Auto Reset Integral (3-mode only)**	0, 0.1, 0.5, 1, 2, or 3 to 100 repeats per minute; determined by position of jumper wire and setting of potentiometer on upper level of controller printed circuit board.
		•	•		**Rate Time Derivative (3-mode only)**	0, 0.5, 1, 2, 5, or 10 minutes; determined by position of jumper wire on upper level of controller printed circuit board.
		•	•		**Proportional Band**	*Single mode:* 2, 5, or 10 percent of span; determined by position of jumper wire on controller printed circuit board. *Three mode:* continually adjustable from 1% to 100% of span; potentiometer accessible on upper level of controller printed circuit board.
		•			**Cycle Time**	10 or 20 seconds; determined by position of controller printed circuit board jumper wire.
			•		**Direct Output Action**	Printed circuit board jumper wire change from standard Reverse output action.
				•	**Manual Reset Button (Limit controller)**	Switch on chart plate resets Limit circuit after process returns to normal.

Wiring	Barrier terminal strip mounted on each controller board; #6 screw terminals. (Figure 5)
Mounting	*Panel:* Brackets supplied for clamping case to vertical panel with 12.7 inch (322.6 mm) square cutout. *Wall:* Surface mounting uses knockouts in back of case for fastener holes suitable for four #10 screws, upper knockouts keyhole-shaped for ease of installation.
Weight (maximum)	13.8 lbs. (6.27 kg).
Dimensions	Refer to Figure 6. (NOTE: Door is off-center to left of panel cutout.)
Accessories	Box of 100 charts, 2 pen cartridges per pen, panel mounting brackets, instruction book.
Approval Bodies	*CSA Listing:* all models *FM Approval:* all models (pending for Cam Prog., Limit Control, and Three-Mode units) *UL Listing:* all models (pending)
Available Kits	Chart illumination (part #24400120–001). Panel cutout adaptor bezel plate (part #24400124–001). Clear acrylic plastic window (part #24400125–001). Set point upper stop kit (part #24400128–001)
Standard Temperature Sensor	A thermocouple assembly may be ordered in Table IV of the model number. Refer to Figure 7 for drawing and description of standard sensor, and the following table for part numbers.

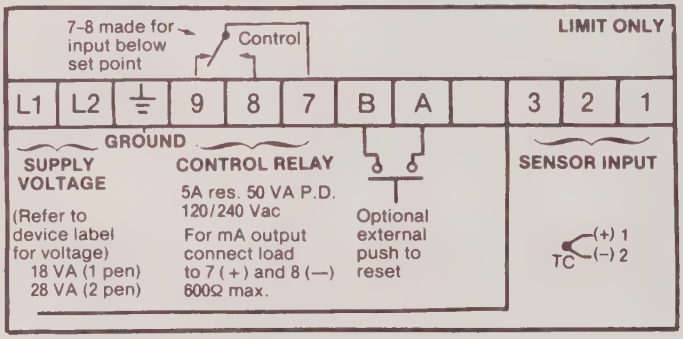
*Registered Trademark



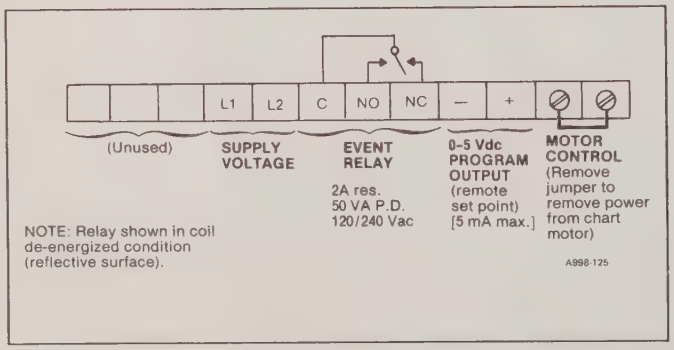
Controller printed circuit board

CAUTION: NON METALLIC ENCLOSURE DOES NOT PROVIDE GROUNDING BETWEEN CONDUIT CONNECTIONS. USE GROUNDING TYPE BUSHINGS AND JUMPER WIRES TO MAINTAIN RACEWAY GROUND CONTINUITY.

NOTE: All relays shown in coil de-energized condition.



Limit control models only

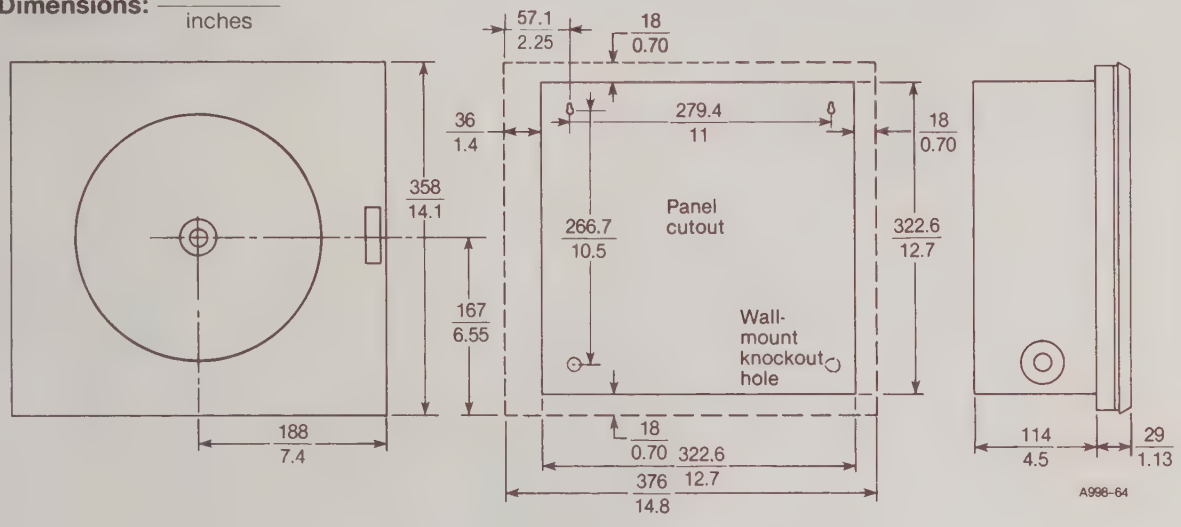


Optical event switching board

NOTE: Relay shown in coil de-energized condition (reflective surface).

Figure 5 – Wiring Connection Diagrams

Dimensions: millimetres / inches



NOTE: Panel cutout hole of off-centered 9 mm (0.35 inches) to the right of the overall instrument outline. Measure cutout spacing and panel layout carefully.

Figure 6 – Mounting Dimensions

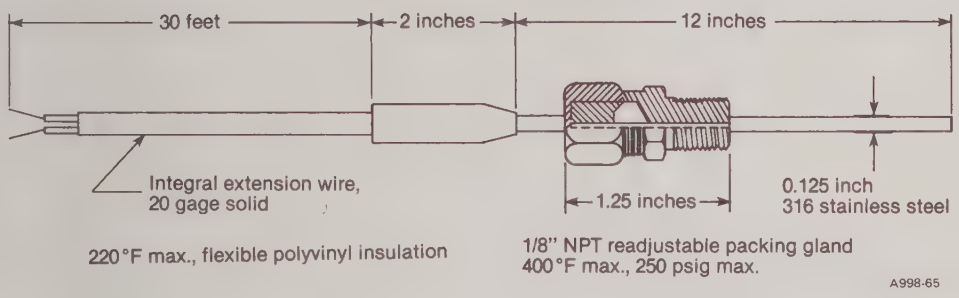


Figure 7 – Standard Thermocouple

Standard Temperature Sensor (Thermocouple)

Type	Model Number / Part Number	Recommended Max. Temp. Long Term	Short Term
T	2T2M15–G12–8T–A360–1W2P6	260°C (500°F)	370°C (700°F)
	24001694–001		
J	2J2M15–G12–8T–A360–3W2P6	595°C (1100°F)	760°C (1400°F)
	24001694–002		
K	2K2M15–G12– 8T–A360–5W2P16	870°C (1600°F)	870°C (1600°F)
	24001694–003		

Options

Control

Alarm
The alarm consists of an internally set, process alarm circuit with SPDT electromechanical relay output. High alarm configuration is standard, but the circuit can be converted to low alarm by changing plug-in jumpers on the printed circuit board. The alarm circuit is located on the main printed circuit board, but it is independent of the recording and controlling functions. The alarm option is not available with limit control selection.

Automatic Reset (Limit Controller Only)
Available as kit part number 24400131-001. Circuitry on plug-in printed circuit card resets the limit control relay automatically on initial start up or after a power failure.

Event Sequencing (Single-pen Models only; not available on Limit Controller)
An optical event switch circuit lets the user set the on/off time sequence of any desired event or device by applying non-reflective bands of varying time-width to the back of the chart. The optical sensor monitors the reflective back of the chart as it rotates, and energizes a relay when a non-reflecting surface passes over it.

The event switch printed circuit board is mounted to the left of the larger main printed circuit board, and has its own screw terminal connections for field wiring. The optical sensor is mounted on the back of the chart plate.

Process Variable (PV) Output (Three-mode Controller only)
This circuit generates a 0 to 5 Vdc output corresponding to the PV signal level. This output may be span-and-zero adjusted independently of the control circuitry, using potentiometers mounted on the upper board level.

Remote Reset (Limit Controller only)
Externally located reset switch is wired to terminals on the printed circuit board.

Case

Chart Illumination
Available as kit part number 24400120-001.

Special Door Glass
Acrylic plastic window available as kit part number 24400125-001.

Specifications are subject to change without notice.

Panel Cutout Adaptor Bezel Plate
Available as kit part number 24400124-001.

Set point Mechanical Stop (#1 Pen SP only)
Available as kit part number 24400128–001

Ordering Data

Refer to the Model Selection Guide, Reference 44-01-16-01, to construct a model number describing the desired instrument.

Honeywell offers a full line of sensors and transmitters that produce a compatible range of dc voltage or current signals which can be used as input to the AR 100 recorder-controller. These devices measure:

- Temperature (thermocouple or RTD)
  Refer to Catalog No. C100 and Specification S920 for additional sensors not listed with this unit's standard thermocouples.
- Pressure
- Flow
- Liquid Level

  } (4 to 20 mA or 1 to 5 Vdc process transmitter)

  Refer to Specifications 31-41-03-01 through 31-41-03-07.
- Humidity (gold grid sensor)
  Refer to Specification 95-5158.

Order From

1. Local Honeywell Branch Office or
2. Honeywell
   1885 Douglas Drive North
   Minneapolis, Minnesota 55422
   (In Canada – Honeywell Limited
   730 Ellesmere Road
   Scarborough, Ontario M1P 2V9).

For more information on Honeywell sensors and transducers, contact:

Honeywell Process Control Division
1100 Virginia Drive
Fort Washington, PA 19034

Series AR 100 Cam Program Recorder-Controller

Specification

Function

Honeywell's AR 100 cam program recorder-controller instruments (Figure 1 and 2) are designed primarily to automatically regulate time-temperature (process variable vs. time) programs on batch processes and environmental chambers where a specific program is repeated periodically or continuously. These instruments also measure and record any variable that can be translated into a voltage or resistance signal, depending upon actuation selected.

Programmers are available with independent control forms and alarm functions as well as an optically activated event switch and a programmed 0-5 Vdc set point output.

Honeywell offers a full line of sensors and transmitters that produce a compatible range of dc voltage or current signals which can be used as input to the AR 100 recorder-controller. These devices measure:

- Temperature (thermocouple or RTD)
- Pressure
- Flow
- Liquid Level

(4 to 20 mA or 1 to 5 Vdc process transmitter)

- Humidity (gold grid sensor)

Description

Enclosure

AR 100 cam program recorder-controller is enclosed in a case that is designed for surface or panel mounting.

The case is of durable foamed Noryl* resin construction with a gasketed, glass windowed door. Knockouts for wiring are provided in the bottom and sides of case. All cases have knockouts and mounting hardware.

A998-120

Figure 1 – Cam Programmer

A998-121

Figure 2 – Oblique View to Show Cam Edge

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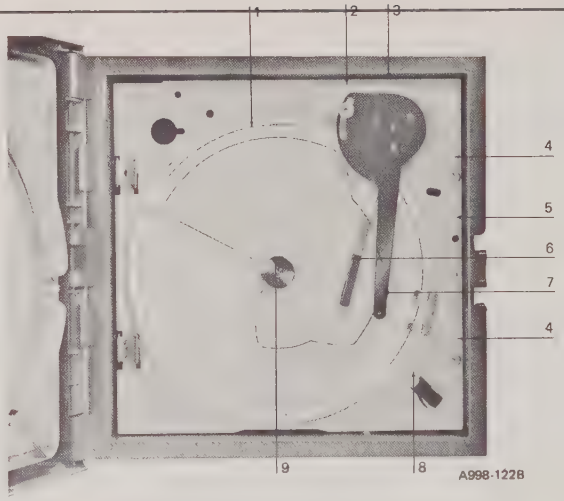
Components

With the door open (Figure 3), the hinged chart plate swings out 90 degrees for convenient component access (Figure 4). The display and cam drive components, as well as some parts of the instrument's servo balance system are located on the chart plate. Display and cam drive components include the 10-inch diameter chart, transparent acrylic plastic cam, cam and chart drive assembly, spring-loaded cam follower arm assembly, and disposable fiber-tip pen cartridge. The chart plate has an access hole for each manual reset adjustment on proportional controllers and time index mark for chart time alignment. Synchronous chart and cam drive motors provide various chart and cam speeds. Tapered hub and locating pin on the chart and cam drive assembly assure correct alignment when the chart is renewed. Assembly has a clutch for initial time alignment, or resetting in case of power interruption. The cam roller portion of the spring-loaded cam follower arm assembly tracks the cam contour, positioning the arm assembly according to the time-temperature program. The arm assembly is mechanically linked to the set point wiper so it will always precisely follow the contour of the cam. The knurled holding the nut allows arm assembly to be held in one position, if the cam isn't being used. The pen arm carries the disposable fiber-tip, snap-on pen cartridge.

The servo balance system consists of solid state circuitry located on the main printed circuit board mounted in the rear of the case and a servo assembly mounted on the back of the chart plate. The system converts the electrical signals from process variable sensors into precise mechanical positions. Basically, this system measures an unknown emf or potential by balancing the unknown emf against a known or calibrated emf established by the position of a contactor on a slidewire.

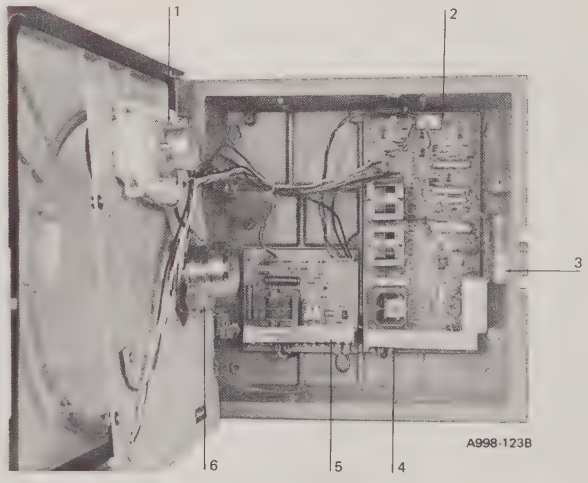
Solid state circuitry integrates power supply, measuring circuit, preamplifier and pen positioning servo functions. Plug-in range resistors make field range changes possible. The servo assembly includes an ac servo motor and a precision wound rebalancing slidewiire; it also includes the set point wiper that generates the control output signal. Servo motor directly drives the wiper and the pen arm for accurate input signal tracking and reliable pen motion. See Control Selections for control form descriptions.

Field wiring connections to the screw terminals on the barrier connector strip at the bottom of the printed circuit board.



LEGEND
1. Plastic Cam
2. Knurled Holding Nut
3. Spring-Loaded Cam Follower Arm Assembly
4. Chart Plate Latching Screws
5. Access Holes for Manual Reset Adjustments
6. Disposable Fiber-Tip Pen Cartridge – Red
7. Cam Roller
8. Optional Chart Illumination
9. Knurled Cam Hold Down Nut

Figure 3 – Door Open



LEGEND
1. Servo Assembly
2. Typical Main Printed Circuit Board
3. Manual Reset Adjustment – Proportional Control
4. Screw Terminals for Field Wiring
5. Optional Event Sequencing or Programmed Set Point Output (or both) Printed Circuit Board
6. Cam and Chart Drive Assembly

Figure 4 – Chart Plate Open

Control Selections

Control form output signals activate remote final control devices (valves, motors, relays, SCR's, etc.) to vary the process according to the cam program. Five types of control forms are offered:

- Two position switching (on/off, high/low)
- One mode time proportioning (with manual reset/offset adjust)
- Three mode time proportioning (with auto-reset/offset adjust)
- One mode current proportioning (with manual reset/offset adjust)
- Three mode current proportioning (with auto-reset/offset adjust)

Solid state control circuitry is located on the main printed cricuit board with the recording servo balance system circuitry and optional alarm circuitry, but each is an independent parallel function. This "thru control" concept assures optimal control sensitivity and speed of response, independent of the recording servo system response.

On/Off or High/Low control action is used in general control applications, usually with slow-changing processes.Typical control elements include triacs, SCR's relays, contractors, solenoid valves, and two-position (ModuTrol) motors.

Control action opens or closes a relay depending on the value of the process variable relative to the set point (above or below).

Time Proportioning control action is useful in application to heating/cooling, moisture controls, or control plus alarm functions. Typical control elements include triacs, SCR's, relays, and contactors.

Control action cycles a relay on and off in proportion to the difference between the process variable input and the set point. Single mode control (proportional band only) is used for processes with little or no load change. Three mode control (proportional band, rate, and auto-reset) is used for processes with frequent load changes.

Current Proportioning control action is especially useful in applications using SCR power packs, saturable core reactors, proportioning ModuTrol motors, and current to pneumatic (I/P) transducers for control of pneumatically operated devices, or control plus alarm functions.

Control action supplies a direct current output (to a final control element) in proportion to the difference between the process variable input and the set point.

Specifications

Operating Conditions

	Reference Conditions	Rated Conditions	Extreme Conditions	Transportation and Storage
Ambient Temperature Range	67 to 77°F 19 to 25°C	40 to 120°F 4.5 to 49°C	30 to 140°F −1 to 60°C	−40 to 151°F −40 to 66°C
Relative Humidity (% RH)	10 to 55	5 to 90*	5 to 95*	5 to 98
Vibration				
Frequency (cps)	0	0.05 to 60	0.05 to 200	
Acceleration (g)	0	0.2	0.5	
Mechanical Shock				
Acceleration (g)	0	0.5	30	
Duration (ms)	0	30	30	
Mounting Position from Vertical				
Tilted Forward	5°	30°	45°	any
Tilted Backward	5°	30°	90°	any
Tilted to Side (±)	5°	10°	20°	any
Power Requirements Vac @:				
50 Hz	240 (or 100)	210 to 245 (95 to 105)	196 to 253 (90 to 110)	
60 Hz	120 (or 100)	110 to 125 (95 to 105)	107 to 127 (90 to 110)	

*Absolute humidity limit of 400 grains H_2O/lb dry air.

Performance

Recorder:	
Accuracy	±1.0 percent of span
Reproducibility	0.5 percent of span
Deadband	0.5 percent of span maximum
Span Step Response Time	10 seconds maximum; 9 seconds minimum (60 Hz)

Specifications (continued)

Inputs:

Thermocouple	*Types:* J, K, R, and T. *Spans:* 8.5 mV minimum, 55 mV maximum. *Maximum Source Resistance:* 500 ohms @ rated conditions; 2500 ohms @ extreme conditions.
Resistance Temperature Detector (RTD)	*Type:* Platinum two- or three-wire (100Ω @ 0°C; and 139.02Ω @ 100°C), or (200Ω @ 0°C; and 278.04Ω @ 100°C), or (500Ω @ 0°C; and 695.1Ω @ 100°C) *Span:* 20 ohms minimum. Leadwire resistance compensation is provided for three-wire sensors having equal resistance in the three leads. Compensation reduces leadwire resistance effect by a factor of at least seven.
Differential RTD (Wet/Dry Bulb)	*Type:* Platinum (100Ω @ 0°C; and 139.02Ω @ 100°C), or (200Ω @ 0°C; and 278.04Ω @ 100°C), or (500Ω @ 0°C; and 695.1Ω @ 100°C) Two, 2-wire sensors combined to form 3-wire unit. *Span:* 12.5 ohms minimum.
Current (mA dc)	*Range:* 4 to 20 mA. *Input resistance:* 2.5 ohms.
Voltage (Vdc, mV dc)	*Ranges:* 0 to 5 Vdc, 1 to 5 Vdc, and 0 to 10 mV dc. *Input Impedance:* 0.8 Megohms minimum.
Relative Humidity	*Type:* Composite gold grid sensor. *Range:* 5% to 98% RH (used with a 0 to 100% chart).
Maximum Rate of Set Point Change	*SP rise:* 1.74% FS per degree of cam rotation, from 0% to 30% of scale 2.0% FS per degree of cam rotation, from 30% to 100% of scale *SP fall:* 50% FS per degree of cam rotation, from 0% to 100% of scale

Controller and Alarm Outputs:

Relay (electromechanical spdt) (For On/Off, High/Low switching or Time Proportioning control forms, Event switching function, or Alarm function)	*Control Relay Contact Ratings:* Resistive load: 5 A @ 120/240 Vac. Pilot duty: 50 VA @ 120/240 Vac. *Event Relay/Alarm Relay Contact Ratings:* Resistive load: 2 A @ 120/240 Vac. Pilot duty: 50 VA @ 120/240 Vac. Alarm at high condition is standard. Low alarm requires field change of plug-in jumpers on circuit board.
Current (For Current Proportioning control form)	*4 to 20 mA dc:* 0 to 600-ohm load. Reverse action (output decreases with increasing input) is standard. Direct action requires field change of plug-in jumpers on circuit board.
Voltage (Remote Set Point/ Programming Output, and PV output from 3-mode controller models)	*0 to 5 Vdc:* (representing 0% to 100% of full scale) Maximum current: 5 mAdc Minimum Load: 1000Ω

Other:

Interference (Stray) Rejection	*Normal Mode:* 50 or 60 Hz: 20 times span. *Common Mode:* 50 or 60 Hz: 30 volts. Dc: 42 volts. *Magnetic Fields:* 0.5 oersted (approximately 39.8 amperes/meter).
Power Consumption	*Controller:* 12 Watts, maximum (with optional event switching function, 16 watts maximum). *Chart Illumination Kit:* 2 Watts.
Thermocouple Burnout Effects	Sensor break protection drives pens upscale as standard. Field change of electrical jumper wires allows downscale response. (Factory calibrated to simulate a 10Ω thermocouple loop resistance.)

Specifications (continued)

Design

Pen	Disposable fiber-tip pen cartridge on stainless steel pen arm.
Circular Chart	10.34 inches (260 mm) diameter; 4 inches (100 mm) calibrated width.
Chart Speeds	24 hours/revolution (15 min./div.) 168 hours (7 days)/revolution (2 hr./div.) 3 days/revolution 8 hours/revolution 4 hours/revolution 1 hour/revolution (available charts printed for "24 hours" or "7 days" only)
No. of Input Channels (Pens)	One continuous input Single pen (red).
Chart Plate	Opens to beyond 90 degrees for access to printed circuit board and wiring terminals; removable.
Case	Gray foamed Noryl* resin; 1/2-inch conduit knockouts for field wiring in bottom and right and left sides.
Door	Beige Noryl* resin; glass window for chart viewing; opens to 105 degrees; gasketed; latched.
Rebalancing Element (Measuring Slidewire)	Precision wirewound slidewire with precious metal contactor serves both the pen positioning servo and the electric control set point reference (cam follower arm).
Program Control (Cam and Follower)	Center point of roller on cam follower arm indicates control set point (roller diameter: 3/8"), clear plastic cam (0.1" thickness plexiglass) cut to specific control pattern for one of the following single mode control forms: Two-Position (On/Off, High/Low) switching, Time Proportioning, or Current Proportioning control.

Adjustments

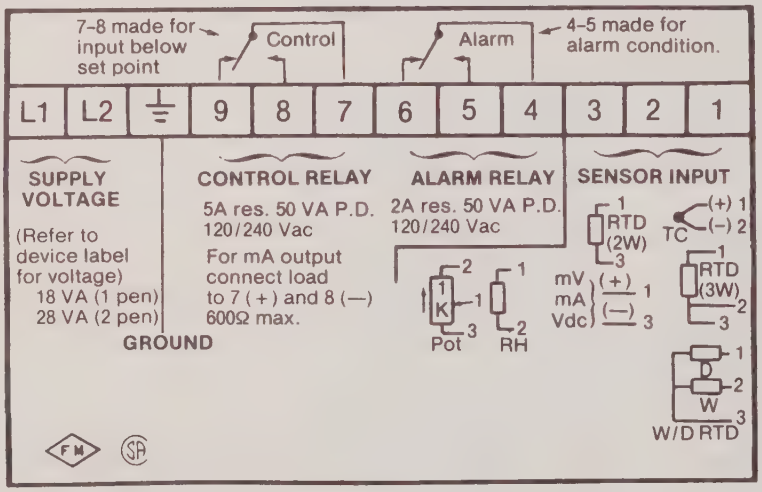
Non Control	Two-Position	Time Proportion	Current Proportion		
•	•	•	•	**Span and Zero Calibration**	Potentiometers accessible on printed circuit board.
•	•	•	•	**Low Alarm Mode**	Printed circuit board jumper wire change from standard high-value alarm mode.
•	•	•	•	**Downscale Thermocouple Burnout**	Printed circuit jumper wire change from standard upscale sensor break response.
•	•	•	•	**Alarm Set Point**	Potentiometer accessible on controller printed circuit board.
	•	•	•	**Manual Set Point Control**	Knurled nut locks follower arm position for operation without a cam.
		•	•	**Manual Reset (offset)**	Potentiometer allows readjustment of offset within the proportional band.
				Auto Reset Integral (3-mode only)	0, 0.1, 0.5, 1, 2, or 3 to 100 repeats per minute; determined by position of jumper wire and setting of potentiometer on upper level of controller printed circuit board.
				Rate Time Derivative (3-mode only)	0, 0.5, 1, 2, 5 or 10 minutes; determined by position of jumper wire on upper level of controller printed circuit board.
		•	•	**Proportional Band**	*Single mode:* 2, 5, or 10 percent of span; determined by position of jumper wire on controller printed circuit board. *Three mode:* continually adjustable from 1% to 100% of span; potentiometer accessible on upper level of controller printed circuit board.
		•		**Cycle Time**	10 or 20 seconds; determined by position of controller printed circuit board jumper wire.
			•	**Direct Output Action**	Printed circuit board jumper wire change from standard reverse output action.

*Registered Trademark

Specifications (continued)

Design (continued)

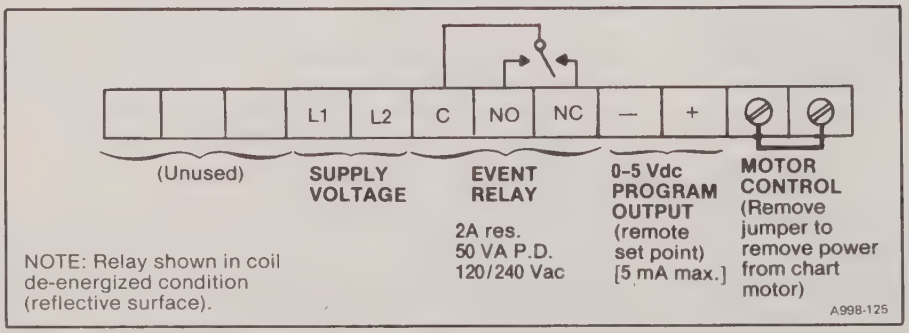
Wiring	Barrier terminal strip mounted on each controller board; #6 screw terminals. (Figure 5)
Mounting	*Panel:* Brackets supplied for clamping case to vertical panel with 12.7 inch (322.6 mm) square cutout. *Wall:* Surface mounting uses knockouts in back of case for fastener holes suitable for four #10 screws, upper knockouts keyhole-shaped for ease of installation.
Weight (maximum)	13.8 lbs. (6.27 kg).
Dimensions	Refer to Figure 6. (NOTE: Door is off-center to left of panel cutout.)
Accessories	Box of 100 charts, 2 pen cartridges, panel mounting brackets, cam blank, cam template for maximum rates of change, instruction book.
Approval Bodies	*CSA Listing:* all models *FM Approval:* all models (pending for Cam Prog., Limit Control, and Three-Mode units) *UL Listing:* all models (pending)
Available Kits	Chart illumination (part #24400120–001). Panel cutout adaptor bezel plate (part #24400124–001). Clear acrylic plastic window (part #24400125–001).
Standard Temperature Sensor	A thermocouple assembly may be ordered in Table IV of the model number. Refer to Figure 7 for drawing and description of standard sensor, and the following table for part numbers.



Controller circuit board

CAUTION: NON METALLIC ENCLOSURE DOES NOT PROVIDE GROUNDING BETWEEN CONDUIT CONNECTIONS. USE GROUNDING TYPE BUSHINGS AND JUMPER WIRES TO MAINTAIN RACEWAY GROUND CONTINUITY.

NOTE: All relays shown in coil de-energized condition.

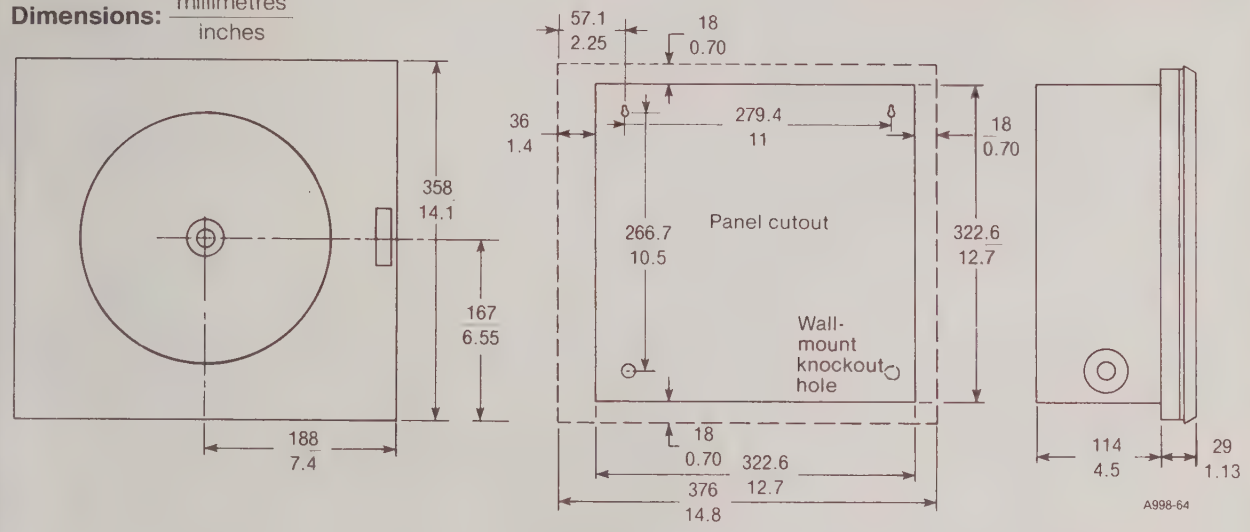


Optical Event Switching and Programming Output (remote set point) board.

NOTE: Relay shown in coil de-energized condition (reflective surface).

Figure 5 – Wiring Connection Diagrams

Dimensions: millimetres / inches



NOTE: Panel cutout hole is off-centered 9 mm (0.35 inches) to the *right* of the overall instrument outline. Measure cutout spacing and panel layout carefully.

Figure 6 – Mounting Dimensions

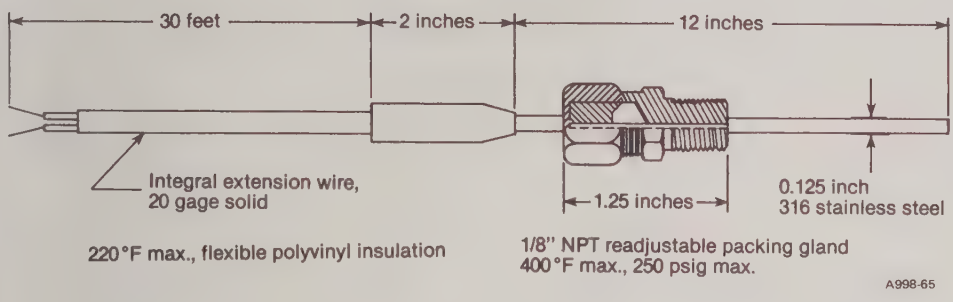


Figure 7 – Standard Thermocouple

Standard Temperature Sensor (Thermocouple)

Type	Part Number	Model Number — Long Term	Recommended Max. Temp. — Short Term
T	2T2M15–G12–8T–A360–1W2P6 — — — — — — — — — — — 24001694–001	260°C (500°F)	370°C (700°F)
J	2J2M15–G12–8T–A360–3W2P6 — — — — — — — — — — — 24001694–002	595°C (1100°F)	760°C (1400°F)
K	2K2M15–G12– 8T–A360–5W2P16 — — — — — — — — — — — 24001694–003	870°C (1600°F)	870°C (1600°F)

Options

Control

Alarm
Internally set, process alarm circuit with SPDT electromechanical relay output. High alarm configuration is standard, but the circuit can be converted to low alarm by changing plug-in jumpers on the printed circuit board. The alarm circuit located on the main printed circuit board, but it is independent of the recording and controlling functions.

Event Sequencing
An optical event switch circuit lets the user set the on/off time sequence of any desired event or device by applying non-reflective bands of varying time-width to the back of the chart. The optical sensor monitors the reflective back of the chart as it rotates, and energizes a relay when a non-reflecting surface passes over it.

The event switch printed circuit board is mounted to the left of the larger main printed circuit board, and has its own screw terminal connections for field wiring. The optical sensor is mounted on the back of the chart plate.

Programmed Set Point Output
This circuit generates a 0 to 5 Vdc output corresponding to set point positions from 0 to 100% full scale. This signal can be used as a remote set point for external controllers, such as Honeywell's Dialapak and DialaTrol, to program multiple control loops from one master cam program.

Circuitry located on the printed circuit board mounted to the left of the larger main printed circuit board has its own screw terminal connections for field wiring.

Event Sequencing and Programmed Set Point Output
Both circuit options are supplied on the printed circuit board mounted to the left of the larger main printed circuit board.

Process Variable (PV) Output (Three-mode Controller only)
This circuit generates a 0 to 5 Vdc output corresponding to the PV signal level. This output may be span-and-zero adjusted independently of the control circuitry, using potentiometers mounted on the uppor board level.

Case

Chart Illumination
Available as kit part number 24400120-001.

Special Door Glass
Acrylic plastic window available as kit part number 24400125-001.

Panel Cutout Adaptor Bezel Plate
Available as kit part number 24400124-001.

Ordering Data

Refer to the Model Selection Guide, Reference 53-01-16-01, to construct a model number describing the desired instrument.

Honeywell offers a full line of sensors and transmitters that produce a compatible range of dc voltage or current signals which can be used as input to the AR 100 recorder-controller. These devices measure:

- Temperature (thermocouple or RTD)
  Refer to Catalog No. C100 and Specification S920 for additional sensors not listed with this unit's standard thermocouples.
- Pressure
- Flow
- Liquid Level

  (4 to 20 mA or 1 to 5 Vdc process transmitter)
  Refer to Specifications 31-41-03-01 through 31-41-03-07.
- Humidity (gold grid sensor)
  Refer to Specification 95-5158.

Order From

1. Local Honeywell Branch Office or
2. Honeywell
   1885 Douglas Drive North
   Minneapolis, Minnesota 55422
   (In Canada – Honeywell Limited
   740 Ellesmere Road
   Scarborough, Ontario M1P 2V9).

For more information on Honeywell sensors and transducers, contact:

Honeywell Process Control Division
1100 Virginia Drive
Fort Washington, PA 19034

Specifications are subject to change without notice.

Series AR100 Recorder-Controllers and Cam Programmers

Technical Data

Introduction

Honeywell's AR100 Recorder-Controller and Cam Programmer systems are structured on a "thru-control" concept – independent parallel recording, automatic control, and alarm functions. The block diagram (Figure 1) shows these functions, as well as the common measuring circuit and preamplifier, the power supply outputs, and the optional programming (remote set point) output and event switching functions. The following descriptions examine how the individual functions work.

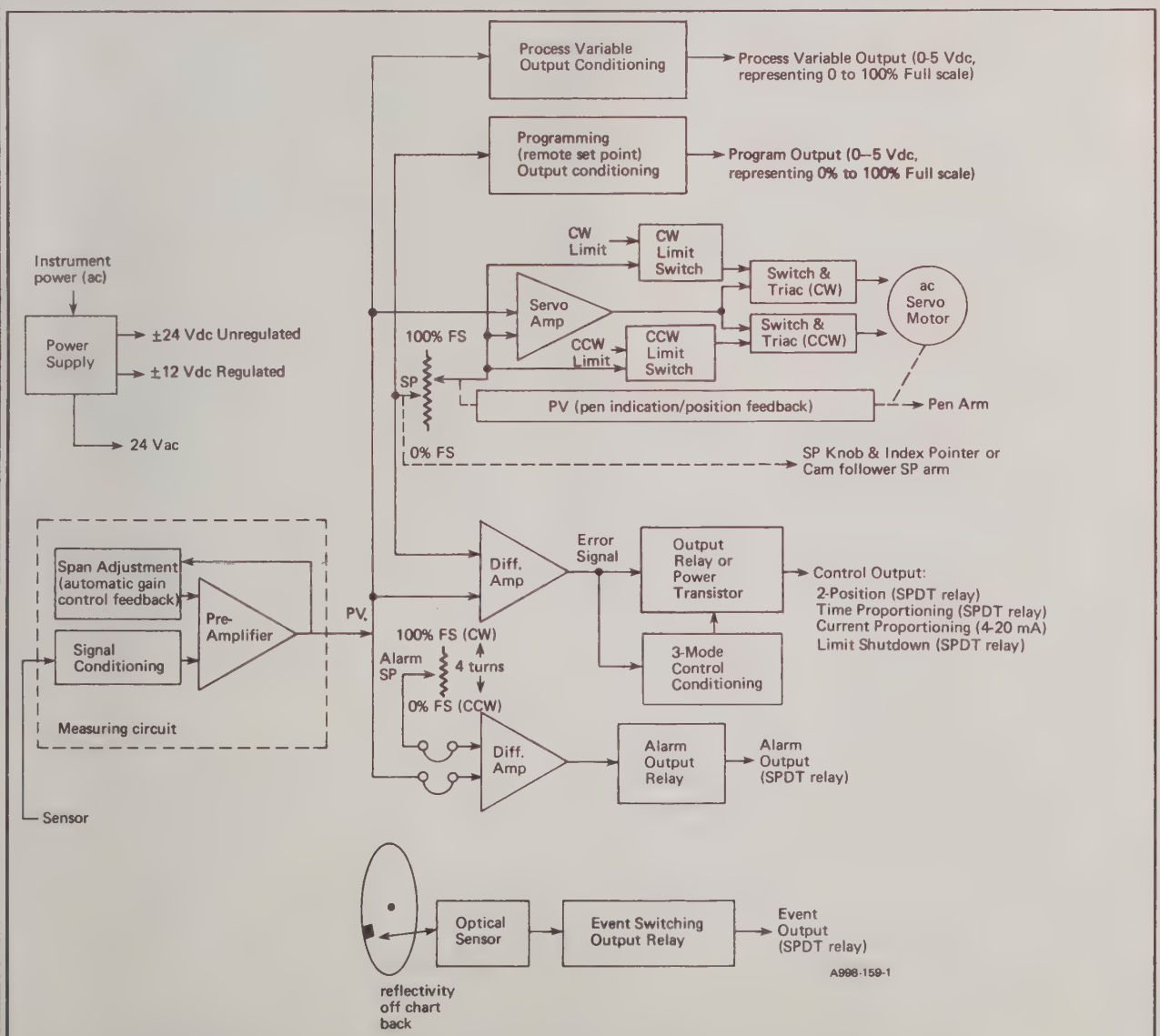


Figure 1 – Operational Block Diagram

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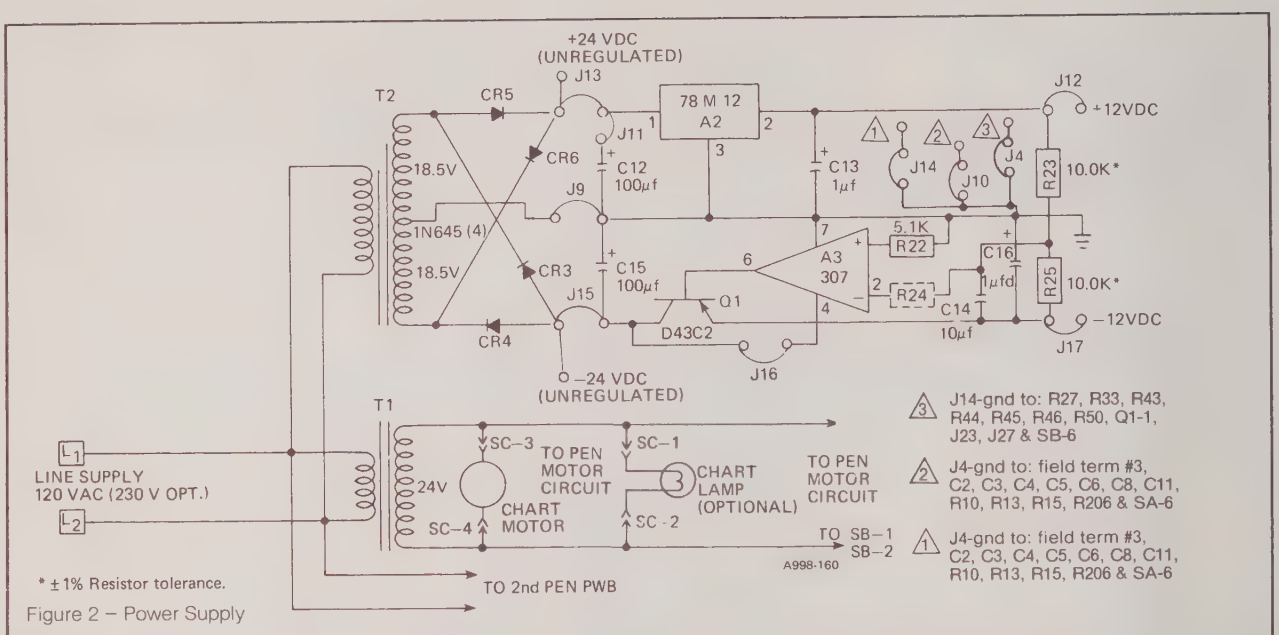


Figure 2 – Power Supply

Power Supply

The power supply (Figure 2) accepts the ac line votlage and transforms it to 37 Vac (center tapped) and 24 Vac. Different transformers are used for 120 vac and 230 Vac line voltages. The 24 Vac powers the Chart Drive Motor, the ac Servo Motor, the optional illumination kit, and the Q457B Relative Humidity Sensor. The 37 Vac winding feeds a full wave rectifier and filter which results in a ±24 Vdc unregulated voltage. The ±24 Vdc drives (a) output relays for control or alarm functions, and the 4 to 20 mA power transistor (and the external load) for current proportioning control output, and (b) the precision ±12 Vdc stages of the power supply. A 3-terminal integrated circuit voltage regulator in the +24 Vdc line generates the precision ±12 Vdc. A tracking regulator (operational amplifier plus power transistor) in the −24 Vdc line references the +12 Vdc and produces the −12 Vdc. The ±12 Vdc is used by the thermocouple input circuit for automatic cold junction compensation and for burnout signals. The ±12 Vdc also supplies voltages for the RTD, the Zero Adjust, the integrated circuit supply, the measuring slidewire, and the Alarm set point slidewire.

Chart Drive

The chart drive mechanism consists of a 24 Vac synchronous motor for 60 Hz or for 50 Hz with internal gear trains for different speeds (time per revolution). The motor, powered from a plug-in connection on the printed circuit board, drives a precision hub containing a drive peg. The taper of the hub and the drive peg ensure accurate chart mounting and prevent chart slippage. The hub may be rotated on its clutch to establish proper chart time alignment. Timing accuracy will be that of the frequency of the ac power supplied to the instrument.

Measuring Circuit

The measuring circuit of these instruments incorporates the pre-amplifier as part of its operation, not merely as a separate following stage. The pre-amplifier operates in conjunction with other elements of the measuring circuit to perform sensor-signal conditioning and electric scaling of the signal level. Seven different input signal conditioning circuit types are available to match the outputs from the following sensors.

Sensors

mV dc, Vdc, mA dc Sensor Signal

Millivolt input signals (Figure 3) are introduced on terminals #1 (plus) and #3 (minus) and are routed directly to the pre-amplifier. Burnout protection, as with thermocouple actuations, is provided on millivolt actuations.

Volt input signals are introduced on terminals #1 (plus) and #3 (minus) which are also bridged by 1 megohm and 4990 ohm resistors. The fraction of the signal appearing across the 4990 ohm resistor is routed directly to the pre-amplifier.

Milliamp input signals are introduced on terminals #1 (plus) and #3 (minus) which are also bridged by a 2.49 ohm resistor. The IxR voltage developed across the 2.49 ohm resistor is routed directly to the pre-amplifier.

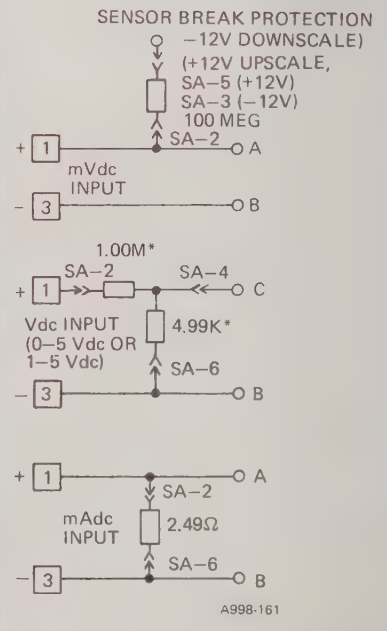


Figure 3 – mV dc, Vdc, mA dc Input

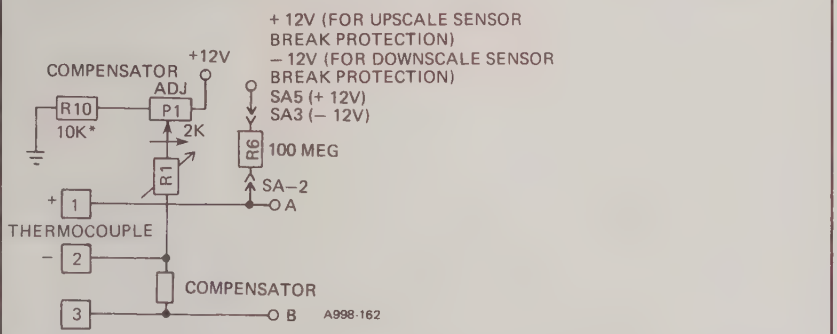


Figure 4 – Thermocouple Input

Thermocouple

Thermocouple sensors (Figure 4) must have their cold junction (instrument connection) referenced to 0°C (32°F) for the microvolts generated at the hot junction (process measurement point) to be meaningful. (The thermocouple principle is based on the voltage produced by the temperature difference between hot and cold junctions of the pair of dissimilar metals making up the thermocouple circuit.) The cold junction (instrument terminals #1 positive and #2 negative) temperature will vary as the ambient temperature inside the case at the connection terminal varies. To detect this cold junction temperature and its changes, a compensator resistor (which has a high positive temperature coefficient of resistance) is mounted between terminals #2 and #3. The compensator (cold junction reference resistor) has a controlled amount of dc current through it so the thermocouple compensating voltage is the IxR voltage drop of this resistor. This compensating reference millivoltage, which varies with the compensator resistance changes (due to the ambient temperature changes at the instrument terminals), is algebraically added to the thermocouple millivoltage and the sum is routed to the input of the pre-amplifier. Since the amount of compensating voltage is a characteristic of the particular thermocouple type (J, K, T, R, etc.), the dc current through the compensator must be uniquely set for each thermocouple type. Measuring circuit resistor R1 and adjustable potentiometer P1 are located in series with the +12 Vdc and the compensator to establish the proper current flow.

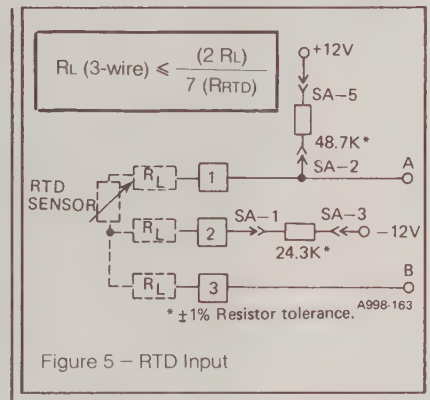


Figure 5 – RTD Input

Thermocouple Burnout is achieved by inserting a minute positive (upscale) or negative (downscale) dc current into the positive lead signal of the thermocouple input. To minimize the effect of the burnout signal on the thermocouple, the current is obtained from the 12 Vdc through a 100 megohm resistance. However, should the thermocouple loop become open circuited, the full 12 Vdc is routed to the input of the pre-amplifier to drive controls, alarms and recording pens to their extremes.

Resistance Thermometer Detector (RTD)

RTD's (Figure 5) produce a resistance change at the bulb with temperature change at the sensor's process location. The 12 Vdc supplies power the RTD through current limiting resistors so that the dc current through the RTD is kept to a nominal 250 microamps. The basic excitation of the RTD is provided at terminals #1 and #3. To achieve compensation for leadwire resistance, a 3 wire installation must be made with leadwires from terminals #2 and #3 connected at one side of the RTD element. With the 3 wire system and all leads of equal resistance, the effective leadwire resistance added to the sensor resistance is significantly reduced (to less than one seventh of the actual leadwire resistance).

Differential Resistance Thermometer Detector (ΔRTD)

Differential RTD's (Figure 6) normally measure small temperature differences, such as the degrees of depression between wet and dry bulb sensors, rather than absolute temperature. Hence one bulb must be viewed as the reference

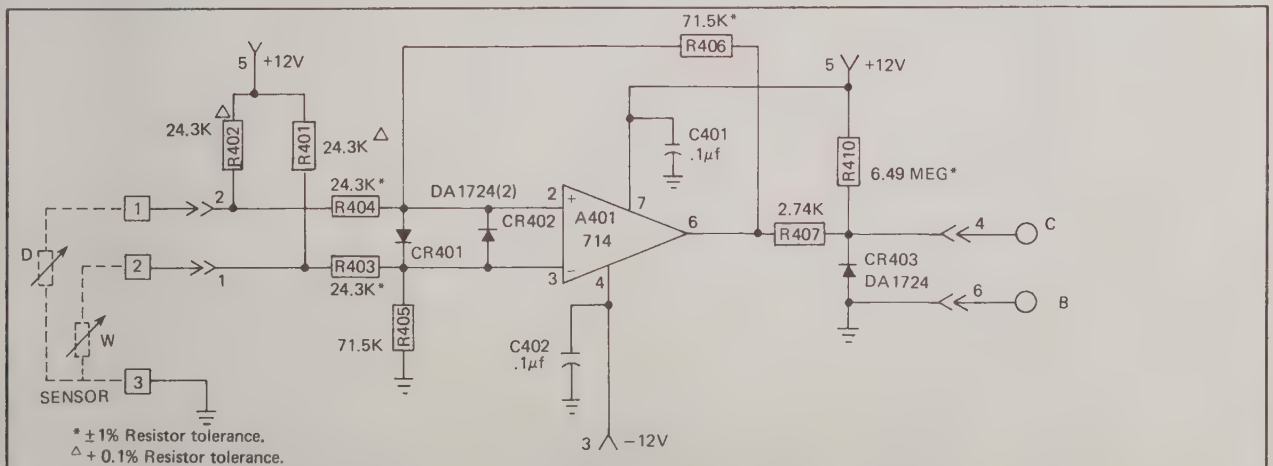


Figure 6 – ΔRTD Input

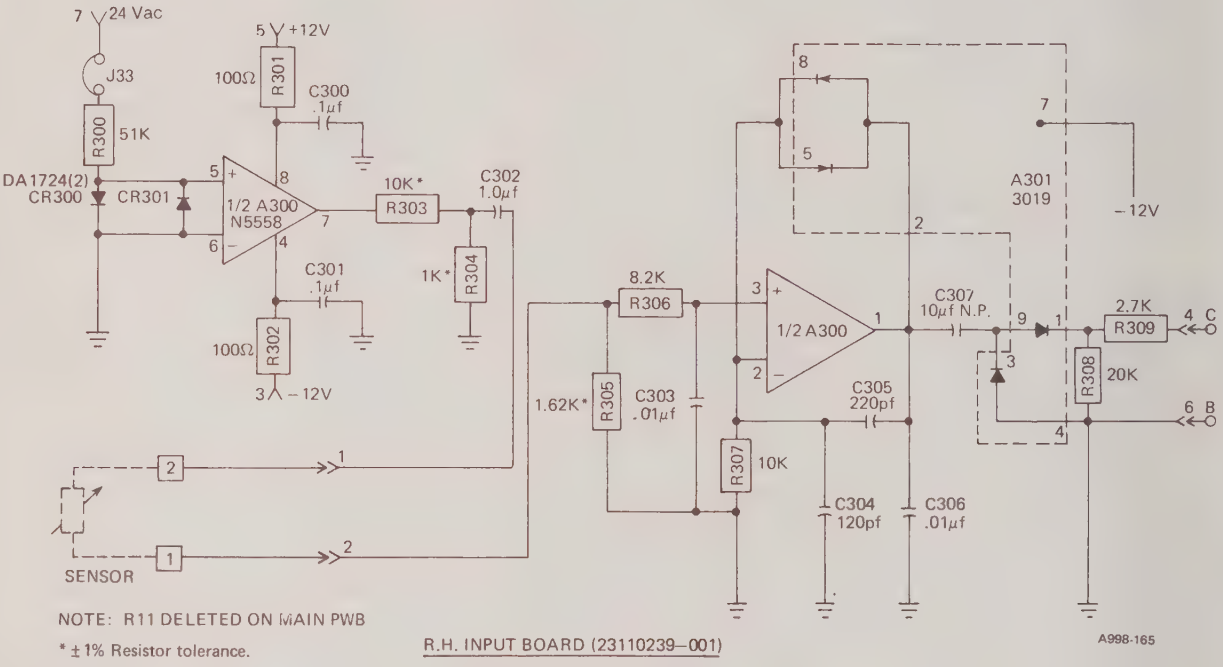


Figure 7 – RH Sensor Input

(even though its temperature may vary with time) and the other bulb is considered to be the measuring, or delta T, bulb. With the Reference Bulb connected to terminals #1 and #3 and the delta T bulb to terminals #2 and #3, the signal input is the differential of the bulbs. Leadwire material and length to both should be the same. A low level differential amplifier raises the signal to the millivolt level for input to the preamplifier.

Relative Humidity

The Q457B Relative Humidity Sensor (gold grid composite) must be powered by an ac voltage (Figure 7). The sensor receives ac excitation through half of A300 (across terminals #1 and #2). The sensor's resistance change with % RH modifies the excitation voltage to an ac signal. The ac signal is converted (in the other half of A300) to a dc millivolt signal which then is routed to the preamplifier. No ambient temperature compensation is provided. If temperature compensation is required, use the Q457A Sensor with the SSP145A signal conditioner and a standard AR100 instrument having a 0 to 10 mV dc range.

Potentiometer/Slidewire

The slidewire of a potentiometer sensor (Figure 8) receives a fixed millivoltage from across terminals 2 and 3. The wiper is mechanically positioned by the measured process variable, which sets a portion of the slidewire millivoltage across terminals 1 and 2 to represent the process variable level. The sensor input operation is similar to mVdc and thermocouple sensors, including "burnout" (open circuit) protection.

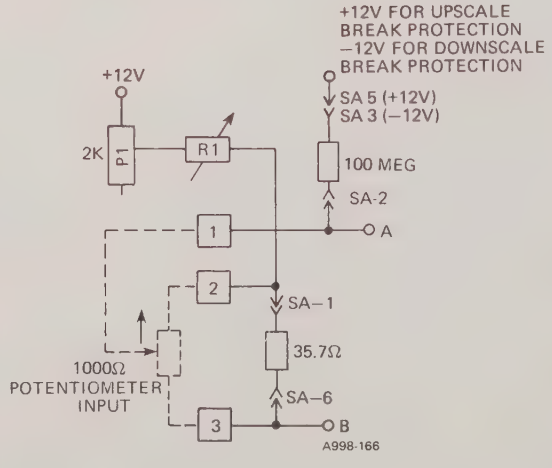


Figure 8 – Potentiometer/Slidewire Input

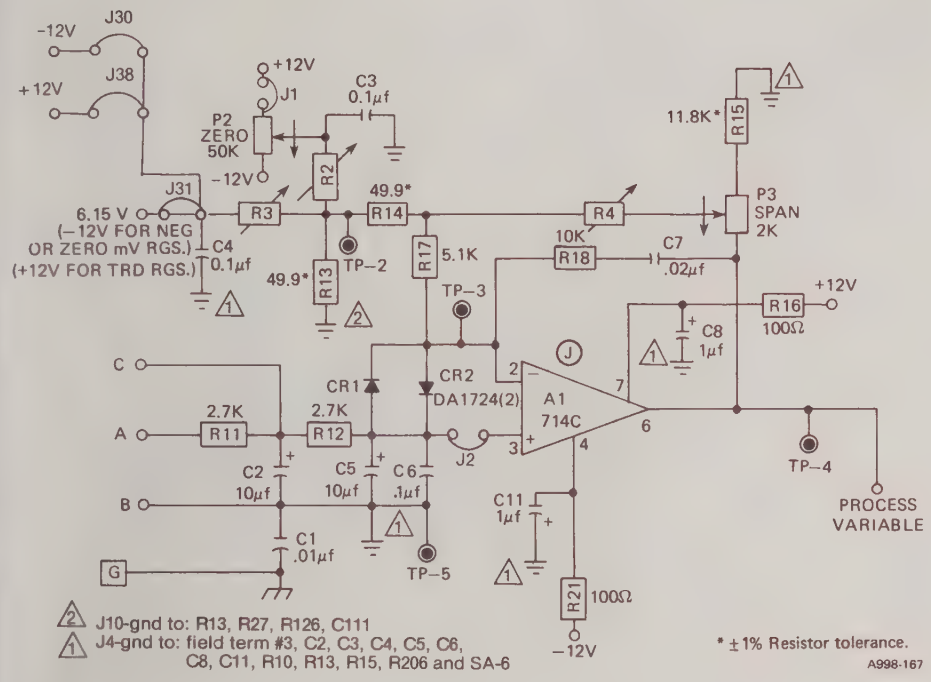


Figure 9 – Measuring Circuit and Pre-Amplifier

Pre-Amplifier

The pre-amplifier circuit (Figure 9) provides:

- Input signal filtering (via resistor/capacitor networks)
- Protection (via diodes) from over-range input signals
- Offset (zero suppression or elevation) calibration and adjustment
- Gain (span) calibration and adjustment.

The pre-amplifier is a type 714C low temperature drift integrated circuit operational amplifier. Its output is the high level Process Variable (PV) signal used by the automatic control, alarm, and pen servo systems. Measuring circuit resistors R2 and R3, in conjunction with the Zero Adjust (screwdriver-positioned potentiometer P2), set the low end of the calibrated range of the system by establishing a precision reference voltage equal to 0% of scale. The chosen span of the calibrated range then determines the operational amplifier gain. Gain is set by the feedback around the operational amplifier. Measuring circuit resistor R4, in conjunction with the span adjust (screwdriver-positioned potentiometer P3), determines the span. The span value added to the Zero reference voltage produces the full scale level of the system's calibrated range. Both the zero and span adjustments provide a range of field calibration adjustments equal to ±3% of the span; hence, field calibration has good resolution and can be accomplished accurately and easily.

The input resistance of the measuring-circuit/pre-amplifier combination is very high (approximately 0.8 megohm or greater), except for the low resistance shunt used in the milliamp actuation. Hence the AR100 instrument circuitry has a negligible loading effect on the external sensor. Further, this type of front end input circuitry does not produce a feedback voltage to the sensor. Therefore, an AR100 controller can work in parallel with other devices, such as DialaTrol or Dialapak controllers, from a common thermocouple or other voltage generating sensor or source. (NOTE: Parallel instruments cannot be operated from sensor types which must be powered, such as an RTD, a potentiometer/slidewire transducer, or a gold grid relative humidity sensor.

The high level PV output from the pre-amplifier is used by the recording, the automatic control, and the alarm functions. All three functions operate independently of each other, but use a similar concept: a differential amplifier compares the high level PV voltage to a reference voltage and the output of the differential amplifier drives a power control network.

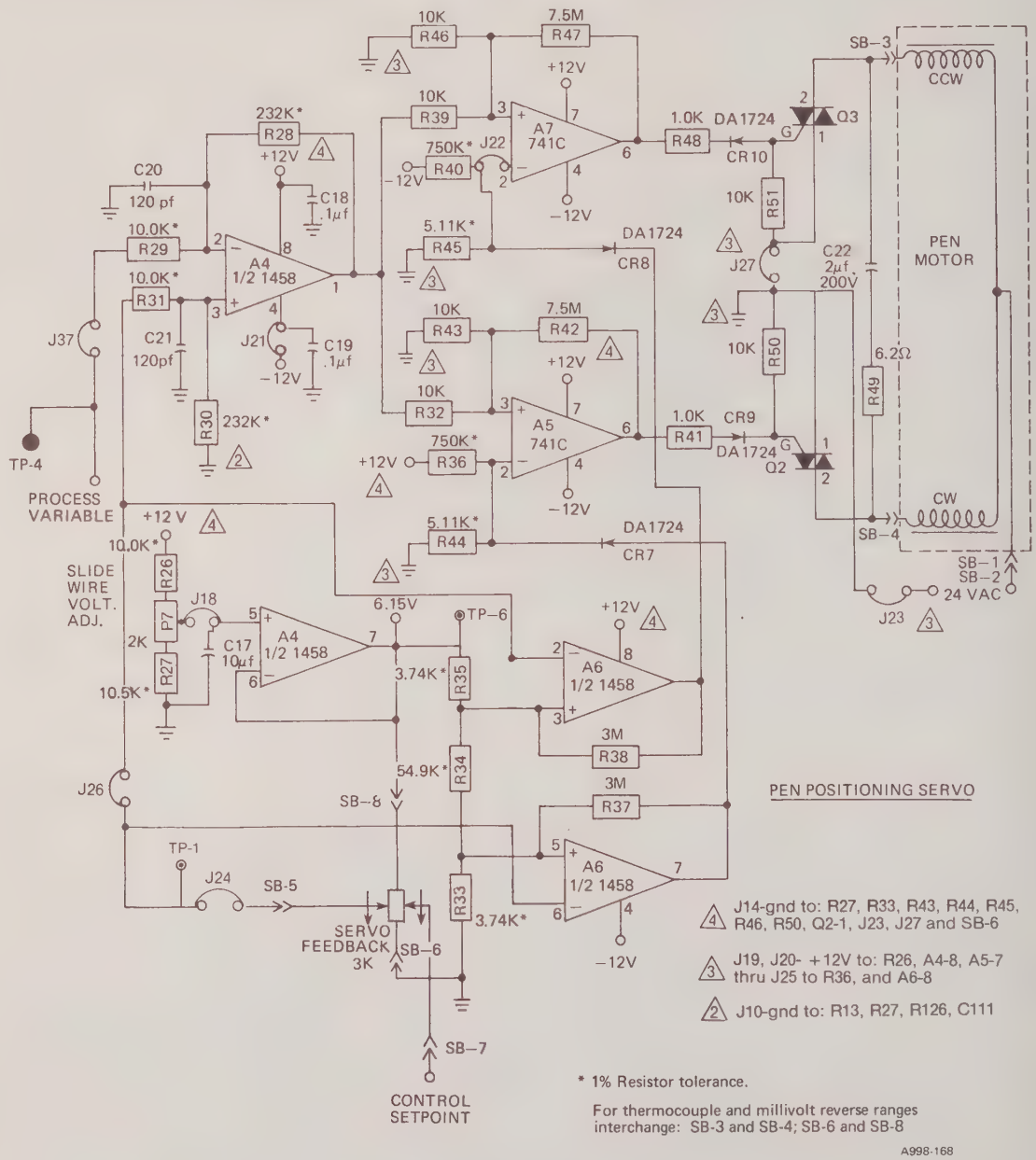


Figure 10 – Pen-Position Servo

Pen-Position Servo

The Pen Position Servo (Figure 10) uses a differential amplifier (A4, type 1458) to compare the high level PV with the slidewire wiper PV. Any difference voltage, the servo error voltage, operates either the clockwise or the counterclockwise ac servo motor winding to drive the slidewire PV wiper to the zero error voltage position. The pen is mechanically linked to the slidewire PV wiper. (The recorder deadband is 0.5% of span, maximum.) To minimize "hunting", the servo error voltage is fed to polarity sensitive, biased comparators (A5 and A7, type 741C) so that, in fact, the error signal must reach a factory set level before actuating the triac (type HI23SS) that switches 24 Vac to the servo motor winding. This design concept, called a "bang-bang" servo, has the advantages of high reliability and high torque output. Since the servo motor and slidewire wiper PV can be driven to the limits by a burnout or other over-range signal, the circuit also contains two comparators (in A6) to serve as high and low limits and to prevent further motor drive beyond the limits which are established by resistors R33, R34, and R35.

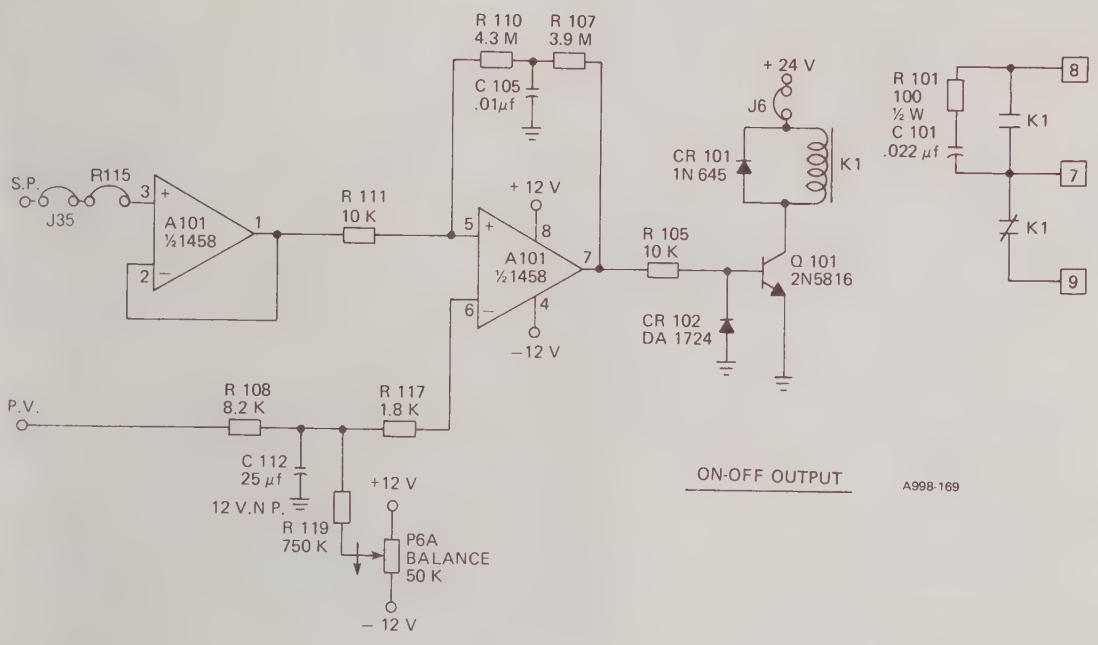


Figure 11 – Two-Position Control

Automatic Control

Control is obtained by using a differential amplifier (type 1458) to compare the high level PV with the slidewire wiper SP. Any difference voltage, the control error voltage, initiates control action. Note the slidewire has two separate and independent wipers: the PV wiper and the SP wiper are mounted to move over the front and rear convolutions of the same slidewire. This arrangement ensures that the recording system and the automatic control system are operating from the same electrical reference. Further, since the PV wiper is mechanically attached to the Pen and the SP wiper is mechanically attached to the SP Index Pointer, the calibrated chart can be the reference for both systems. With the SP and PV at the same reference point, they are electrically within 1/2 a slidewire convolution of each other. The slidewire voltage is factory set for the range 0.575 to 5.575 Vdc which is the same as the range of the high level PV from the pre-amplifier. This high level of slidewire operation, with the chosen materials for the slidewire (Evenohm) and the slidewire wiper (Neyoro G), enhances the reliability and life of the slidewire and reduces the frequency of required slidewire maintenance. (Slidewire cleaning is recommended at 1–2 million cycles nominally; wiper replacement is generally at 8–12 million cycles.)

Two-Position

The Two-Position controller (Figure 11) uses a differential amplifier (A101) with built-in hysteresis factory set at a nominal 0.5% of span. (The hysteresis circuit helps to minimize relay chatter by the 0.5% of span deadband created.) The control error voltage drives a power transistor (Q101, type 2N5816) which, in turn, drives a 24 Vdc SPDT electromechanical relay. A "balance" potentiometer P6 provides an adjustable offset voltage to the amplifier to shift the operating point of the relay slightly. The effect is comparable to Manual Reset on proportional controllers. The normally open relay contacts make (close) when PV is below the SP, are rated 5A at 120/230 Vac resistive, and 50 VA at 120/230 Vac pilot duty, and are available at terminals #7 (hot) and #8 (load). The normally closed contacts open when PV is above SP and are available at terminals #7 (hot) and #9 (load). An electromechanical relay is used because these devices are more tolerant of misapplication and contact overload than are triacs and SCR's (though these conditions will shorten the relay's life). Also the plug-in electromechanical relay can be replaced without special skills. Relay contact arc suppression is a function of the characteristics of the load and properly should be applied across the load, to enhance the relay's life. Therefore, a 100 ohm resistor plus a 0.022 microfarad capacitor are installed in series between terminals #7 and #8 (most often used terminals), but not across terminals #7 and #9 because of space availability on the printed circuit board.

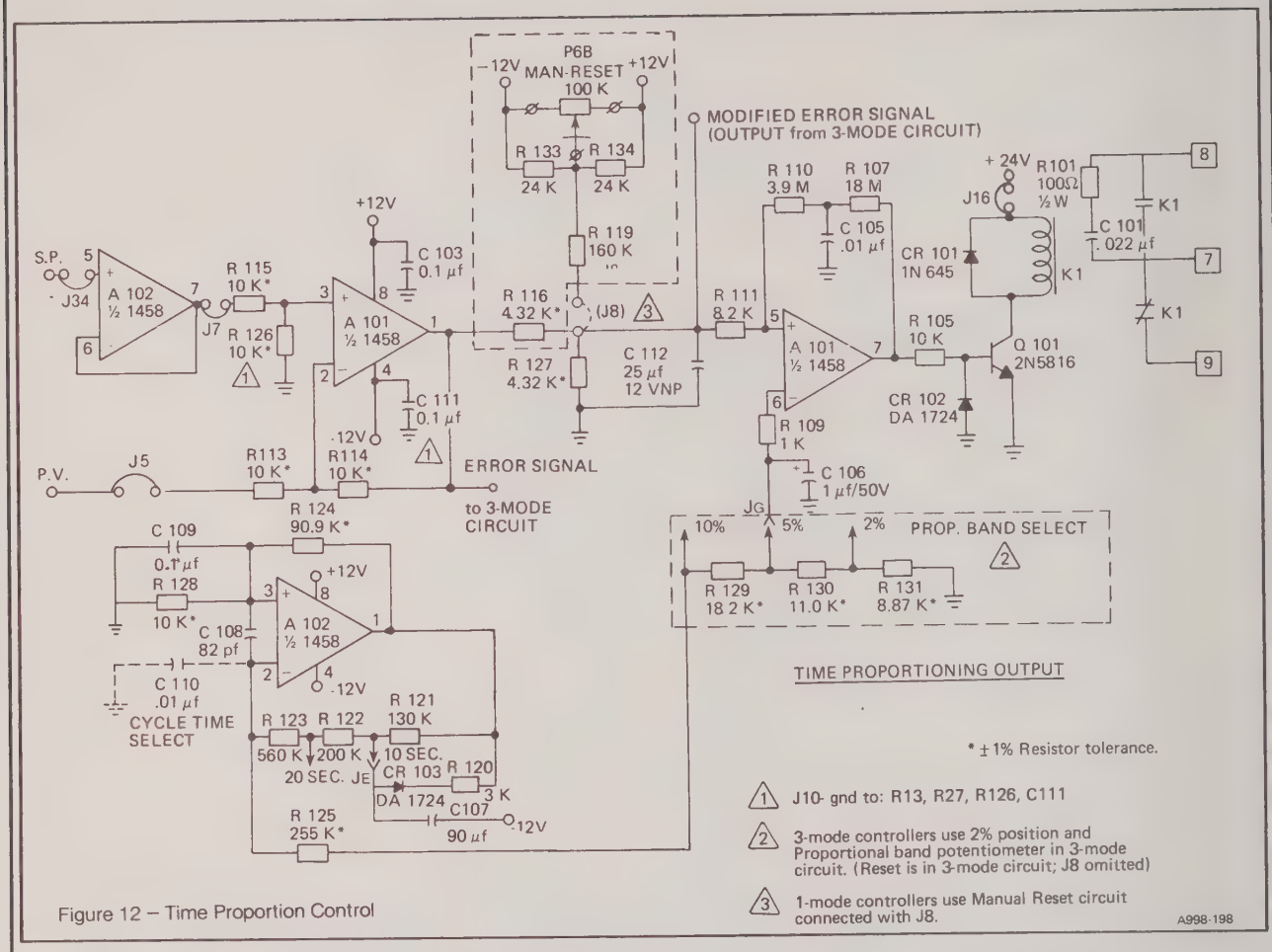


Figure 12 – Time Proportion Control

Time Proportioning

Single Mode

The Time Proportioning controller (Figure 12) is available as a Single Mode Control with Manual Reset system and, like the Two-Position controller, it has the same differential amplifier input and the same electromechanical amplifier is fed to a comparator stage (A101) where the control error voltage is compared to the output of a free-running sawtooth voltage generator (A102). The output of this comparator stage is the percent of time the error voltage is greater than the sawtooth voltage. The amplitude of the sawtooth voltage is selectable by a printed circuit board jumper corresponding to proportional bands of 2, 5, or 10% of span. The period of the sawtooth voltage is selectable by another jumper as a cycle time of either 10 or 20 seconds. Also included is a manual reset circuit which adds or subtracts voltage to the control error voltage signal, thus enabling the percent on-time of the relay to be greater or less than 50% when PV is equal to SP. The manual reset, a screwdriver adjustment (potentiometer P6) to overcome control offset at the SP value (droop or overshoot), is accessible on the right side of the case with the door open. (The operator does not need access to the printed circuit board.)

Three Mode

The Three Mode Time Proportioning controller operates exactly as the single mode controller to generate the initial error signal. However, before the error voltage is compared to the sawtooth voltage it is modified by the Three-Mode Circuit (Figure 13). The single-mode functions of proportional band and manual reset (dotted outlined circuit portion of Figure 12) are replaced by similar functions in the three mode circuit, and the three mode circuit output is fed back to compare the modified error voltage with the sawtooth voltage in A101. The amplitude of the sawtooth voltage is a fixed value and a potentiometer adjustment in the three mode circuit adjusts the error signal voltage. The A101 comparator stage output corresponds to the percent of time the modified error voltage is greater than the sawtooth voltage, as in the single mode controller.

Three-Mode Circuit

The three mode circuitry (Figure 13) modifies the error signal in accordance with chosen settings of rate time, reset action (repeats per minute), and proportional band. The modified error output is fed to the A101 comparator stage of the time- or current-proportioning circuitry (Figures 12 or 14) to complete the control action circuitry.

Rate Action

A voltage divider (R401 and R402) sets the steady-state voltage level at the input of amplifier A401 as a percentage of the error voltage. The amplifier input voltage at any given moment is always determined by the error voltage minus the voltage on capacitor C402. Since the voltage of a capacitor cannot change instantaneously, the amplifier input voltage will change directly with the error voltage and decay to its steady-state value as C402 charges or

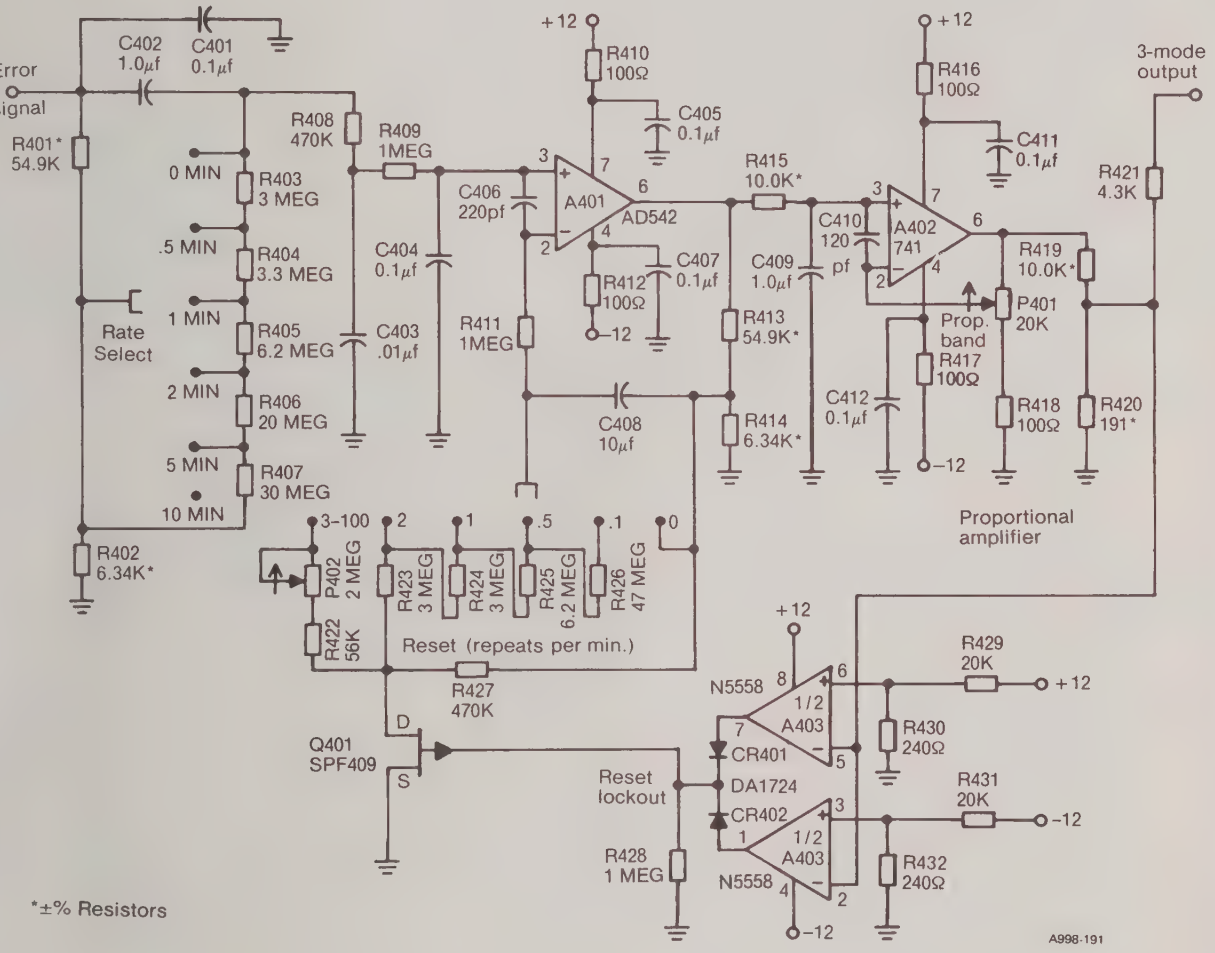


Figure 13 – Three-Mode Circuit

discharges. The amount of time required to reach steady-state is determined by the plug-on jumper selection of resistances in parallel with C402.

Reset Action

The amount of reset action is determined by the plug-on jumper selection of resistances in parallel with capacitor C408. When a non-zero reset value is chosen, C408 charges with the output feedback voltage from amplifier A401. A voltage divider scales the charging voltage level for C408 to be comparable to the error signal from the rate portion of the circuit. The error voltage and the capacitor voltage are added in A401, increasing the amplifier output steadily as C408 continues to charge.

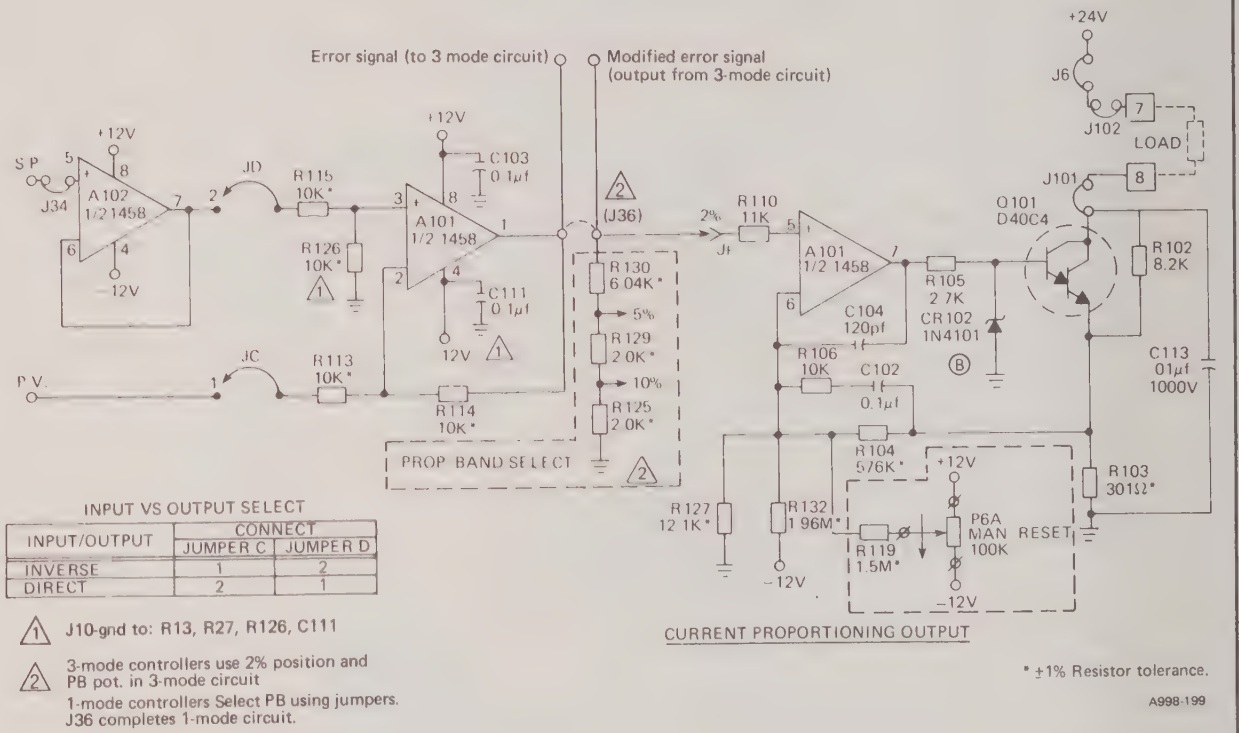
Reset Lockout

If reset action continued uninhibitedly, the output could exceed the controller limits. This effect, called "reset windup", increases the time required for reset effect to decay due to overcharging of C408. The discharge time becomes excessively long and impedes proper controller action. To prevent this, the three mode proportioned error output (from A402) is compared (in A403) with fixed voltage levels corresponding to the upper and lower error limits. An excessive error causes an output from A403 which turns off FET Q401, removing the reference ground from the reset circuit to prevent additional charging of C408.

This halts reset buildup whenever the error output is outside the chosen proportional band.

Proportional Band (PB)

Amplifier A402 accepts the modified error output from amplifier A401 and multiplies it by a gain factor. The gain of A402 is set by feedback from its output through the proportional band potentiometer P401. The gain varies with the resistance ratio of the portion of P401 in the feedback loop to the remainder of P401 and resistor R418. Proportional band is the inverse of gain. The output from A402 is the total modified error signal.



INPUT VS OUTPUT SELECT

INPUT/OUTPUT	CONNECT	
	JUMPER C	JUMPER D
INVERSE	1	2
DIRECT	2	1

1 J10-gnd to: R13, R27, R126, C111

2 3-mode controllers use 2% position and PB pot. in 3-mode circuit
1-mode controllers Select PB using jumpers.
J36 completes 1-mode circuit.

Figure 14 – Current Proportion Control

Current Proportioning

Single Mode

The Current (4-20 mA) Proportioning controller (Figure 14) is available as a Single Mode Control with Manual Reset system. It generates a controller error voltage signal from a differential amplifier in the same manner as the Two-Position and Time Proportioning control circuits. The control error voltage and a voltage proportional to the 4-20 mA output are fed to a comparator stage (A101) whose output is proportional to their difference and drives a Darlington transistor (Q101, type D40C4). The Darlington transistor regulates the 4-20 mA current to the external 0 to 600 ohm load utilizing the +24 Vdc supply. The load is connected to terminals #7 (plus) and #8 (minus). By means of a jumper on the printed circuit board, portions of the control error voltage can be selected corresponding to proportional bands of 2, 5, or 10%. To permit field conversion from the normal reverse acting control sense (12 mA to 20 mA output with PV below SP; 12 mA to 20 mA with PV above SP), a pair of jumpers (JC and JD) on the printed circuit board reverses the PV and SP inputs to the differential amplifier. The Manual Reset enables the operator to adjust the output current to be greater or less than 12 mA when PV is equal to SP so as to overcome control offset (droop or overshoot).

Three Mode

The Three Mode Current Proportioning controller operates exactly as the single mode controller to generate the initial error signal. However, before the error voltage is compared to the current output feedback voltage it is modified by the Three Mode Circuit (Figure 13). The single mode functions of proportional band and manual reset (dotted outlined circuit portions of Figure 14) are replaced by similar functions in the three mode circuit, and the three mode circuit output is fed back to compare the modified error voltage with the current output feedback voltage in A101. The comparator stage output drives the output-regulating Darlington transistor, as in the single mode controller.

Manual Reset Limit Control

The output circuit (Figure 15) accepts the amplified error signal, E_o, and drives the control relay. This circuit consists of a modulator, ac amplifier, trigger, and a power amplifier including the demodulator.

The signal, E_o, is chopped at line frequency by a FET, Q309 driven directly from the secondary of the transformer. R313 and C305 act as a filter to eliminate spikes from the preamplifier. The zener, CR305, shorts the negative wave and cuts the positive at about 8 volts. The chopped input signal, E_o, is then amplified. The ac amplifier is a two-stage amplifier (Q308, Q307). The bias (by CR304) is such that the signal phase cannot be changed by a failure of one of the amplifier components. The amplifier gain, when loaded by Q306, is about 20. The signal is then fed to a trigger circuit.

The trigger circuit, Q306 and Q305, is designed so that if one component fails, it can never work as an amplifier and change the signal phase. As soon as the threshold is reached by the ac amplifier output, the circuit is triggered and the output is a square-wave constant magnitude signal, the phase of which depends on the E_o polarity.

The square wave signal from the trigger circuit is fed into a power amplifier, which is supplied by a half wave voltage in phase with the modulator drive signal. Q304 drives a push-pull circuit (Q301, Q302), Q303 is mounted to increase the gain of Q301. When Q302 is turned on, C302 is discharged through Q302, R301, and CR301, and the relay with C301 in parallel. The relay is not fed directly from the power supply, but only from the discharge of C302.

The power supply of the trigger circuit is half wave (CR303), and demodulation is done by Q304. When the output signal of the trigger is in phase with the half wave of the power supply, the collector of Q304 is clamped to zero. Therefore, C302 cannot be charged, and the relay is dropped out. When the output signal of the trigger circuit is in opposition phase with the half wave of the power supply, Q304 is alternately turned on and off. C302 can be charged and discharged, and the relay is pulled in.

The power supply of the circuit is cut off as soon as the relay drops out. A manual reset pushbutton is connected in parallel with the relay contact, re-energizes the circuit. However, the relay will not pull in again unless the input is of the correct polarity.

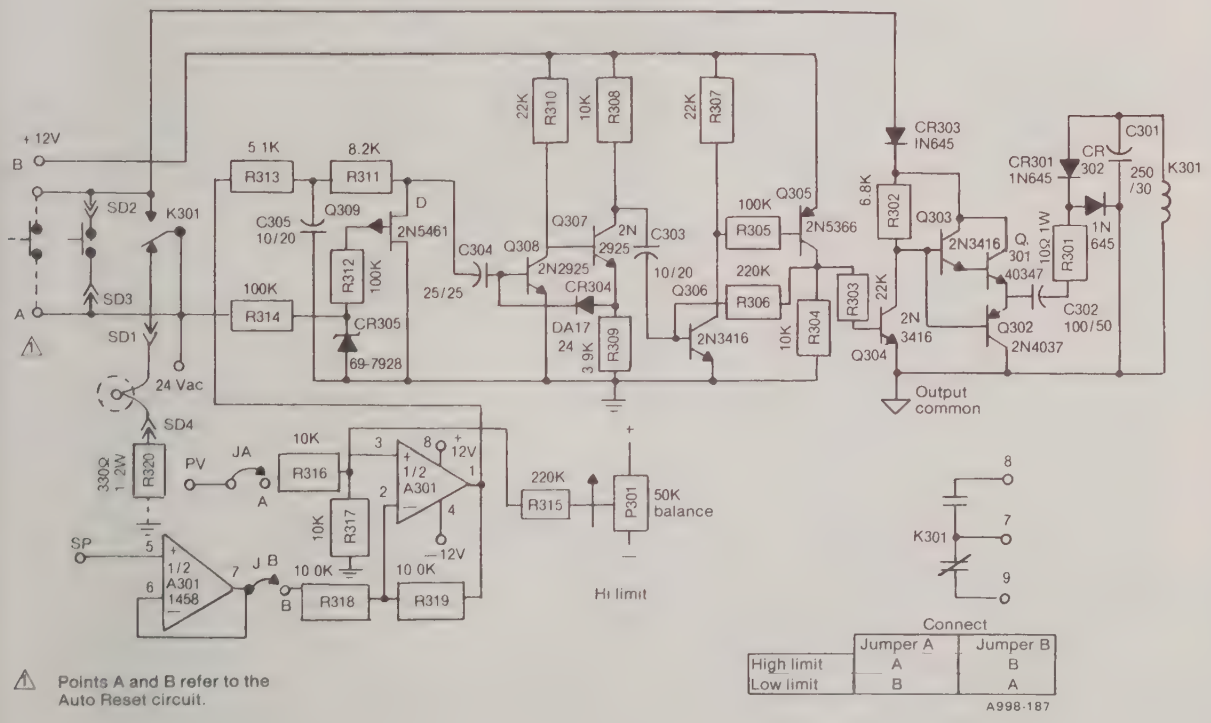


Figure 15 – High (Low) Limit Circuit

An optional plug-in card (Figure 16) is available to reset the relay after a power failure providing the process variable is below the set point (High Limit). A decreasing power supply discharges capacitor C322 on the gate of the FET Q322. When power is restored, relay K321 is closed. The contacts, in parallel with the reset switch, permit the load relay to close and lock in if the process variable is below the set point. The reset relay is closed for about 5 seconds to allow the circuit to stabilize. The timing is a function of the charging rate of capacitor (C322) in the FET (Q322) gate circuit.

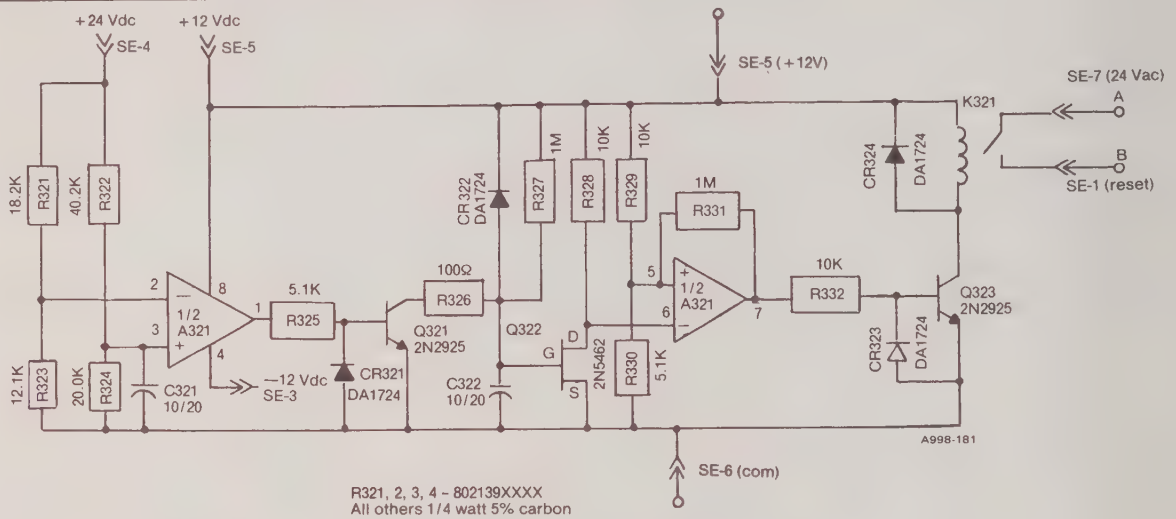
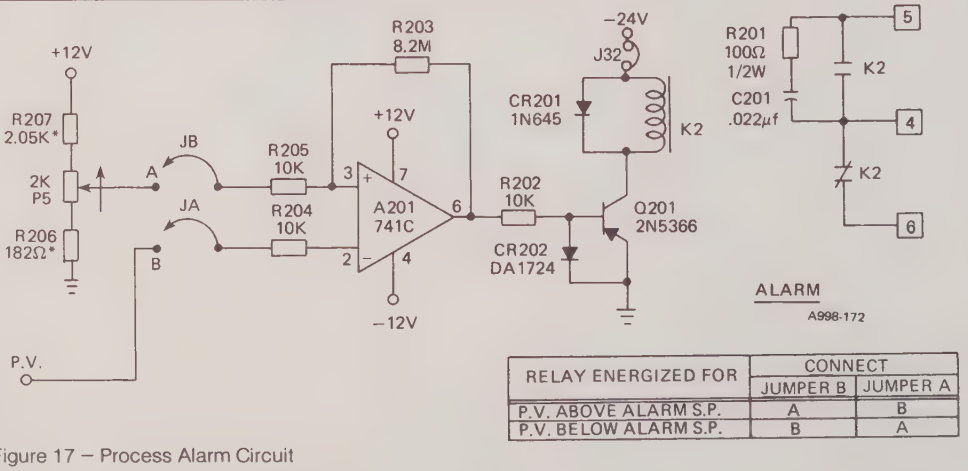


Figure 16 – Auto Reset Circuit



RELAY ENERGIZED FOR	CONNECT	
	JUMPER B	JUMPER A
P.V. ABOVE ALARM S.P.	A	B
P.V. BELOW ALARM S.P.	B	A

Figure 17 – Process Alarm Circuit

Alarm

Process Alarm (Figure 17) is separate from automatic control and is available on non-control and automatic control models. The Process Alarm provides a separate High (or Low) alarm circuit. The Alarm SP is a 4.5 turn screwdriver-type potentiometer (P5) located on the printed circuit board. With the exception of the Alarm SP adjust, the process alarm operates in much the same manner as the Two-Position controller. A differential amplifier compares the high level PV voltage with the Alarm SP voltage to produce an alarm error voltage. The alarm error voltage drives a power transistor (Q201, type 2N5366) which in turn drives a 24 Vdc SPDT electromechanical relay. The alarm contacts, terminals #4 (hot) and #5 (alarm load) are made when the power transistor is turned "ON" by the alarm error voltage. Instruments are usually set to the high alarm model (jumper A to post B; jumper B to post A) so that when the PV is above the Alarm SP the relay will be activated. By reversing the two jumpers (JA and JB) on the printed circuit board, the process alarm can be reversed so as to operate as a Low Alarm. The alarm relay is replaceable, but it is soldered to the printed circuit board. The alarm relay contacts are rated 2A at 120/230 Vac resistive, and 50 VA at 120/230 Vac pilot duty. Like the Two-Position and Time Proportioning controllers, relay contact arc suppression should be sized and applied across the load. An internal 100 ohm resistor, in series with a 0.022 microfarad capacitor, is mounted between terminals #4 and #5, but no suppression is supplied between #4 and #6, the normally closed contacts.

Programming Output

Voltage from the set point wiper (0.575 to 5.575 Vdc) is passed through one-half of amplifier A301 which, as a buffer, isolates the set point wiper from any loading effect from the programming output circuitry (Figure 18). Then the voltage is divided in half by resistors R311 and R312 and fed to one input of the other half of A301 (difference amplifier) for re-amplification to the former voltage level. At the same time, P301 establishes a small offset voltage at the other difference amplifier input. The amplifier input voltages are algebraically added such that the amplified output voltage level is 0 to 5 Vdc.

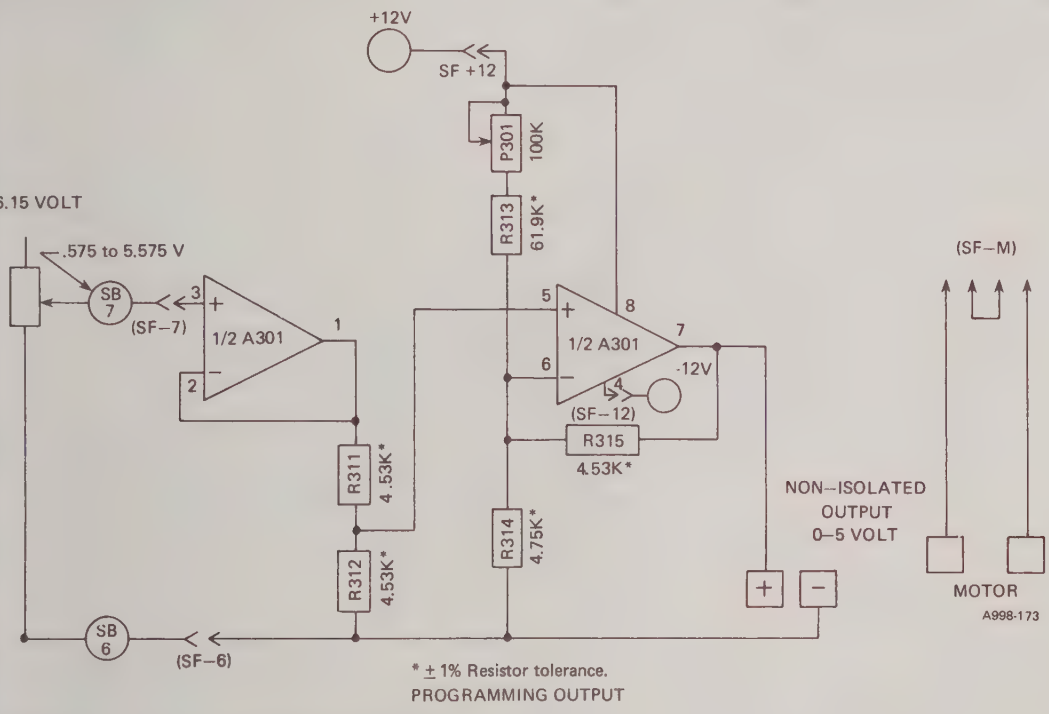


Figure 18 – Program Output (Remote Set Point)

Process Variable Output

The process variable signal passes through one-half of A402 which, as a buffer, isolates the control circuitry from any loading effect from the PV output circuitry (Figure 19). Then the voltage is divided in half by resistors R440 and R441 and fed to one input of the other half of A405 (difference amplifier) for re-amplification to a level between 0 and 5 Vdc. Potentiometer P406 adjusts the span of the PV output by changing the gain of A405. At the same time, P405 establishes an offset voltage at the other difference amplifier input to shift the zero point by approximately ±0.2 Vdc to eliminate any zero offset. The amplifier input voltages are algebraically added to produce the 0 to 5 Vdc output voltage at terminals 1 and 2 (plus to minus).

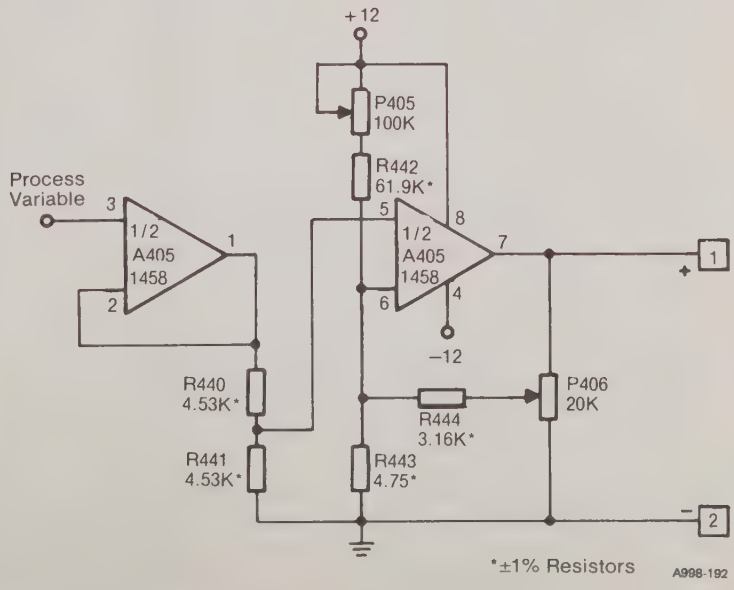


Figure 19 – Process Variable Output

Optical Event Switch

The ac line voltage is transformed to approximately 30 Vac, rectified by CR301 and CR302, and regulated to 18 Vdc by A304 (Figure 20). This dc voltage powers the infrared LED to establish reflection off the chart back. The dc voltage is also impressed across a differential amplifier (A302) through biasing resistors to set an appropriate operating point. The reflected light from the chart back maintains a photo-receiving transistor in a conducting state, shorting one input of the amplifier to ground to establish a difference voltage across the amplifier. The resulting amplifier output back-biases transistor Q301 to prevent conduction of energizing voltage to the event relay. When a black (non-reflecting) band on the chart back passes over the optical sensor: (1) the photo-receiving transistor switches to a non-conducting state; (2) the difference between voltage levels at the amplifier inputs is reduced; and (3) transistor Q301 conducts voltage to energize the event relay. When sufficient light is reflected again from the chart back, the photo-receiving transistor turns on, and the relay is de-energized as Q301 turns off because of the amplifier's biasing output. The event relay is the same type as the Alarm Relay; its contacts are rated 2A at 120/230 Vac resistive, 50 VA at 120/230 Vac pilot duty.

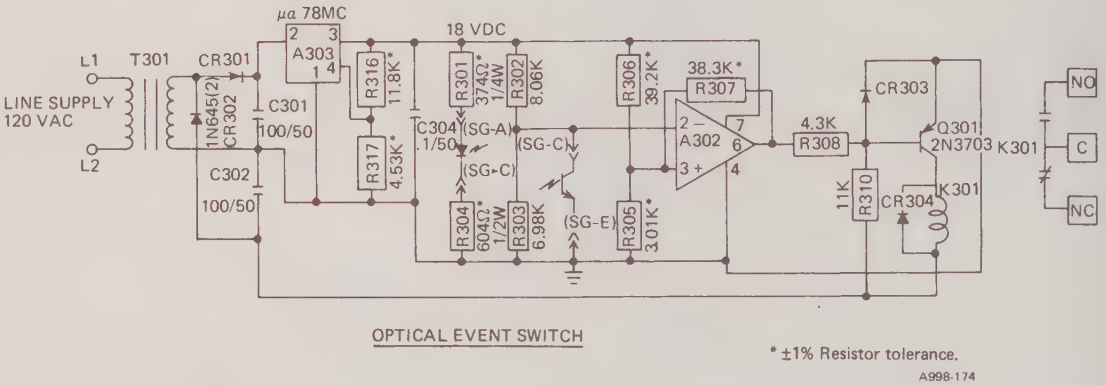


Figure 20 – Optical Event Switch

Series AR 100 Recorder-Controller and Cam Programmer

Installation Data

Introduction

The unit is shipped with its panel mount brackets, fiber-tip pen cartridges and box of charts in separate packages. A cam blank and cam template (for maximum rate of rise) are also included in the packaging of cam program models. Instructions for cutting and installing cams are included in this section. Refer to the Operating Data section for procedures to install charts and pen cartridges.

Mounting

Select a suitable mounting location on a wall or in a panel. Figure 1 gives panel cutout dimensions, and notes the offset between cutouts and sides of door.

Panel Mounting

The mounting kit includes brackets and screws for panel mounting. Insert the instrument through the panel hole from the front. Attach the brackets into the side slots from the rear of the case. Install and tighten screws to push brackets into the back of the panel and pull the case flush onto the panel.

NOTE: On lightweight aluminum panels it may be desirable to place a metal or wood pad between the bracket and the panel back to avoid panel distortion from bracket pressure.

Surface Mounting

If the recorder is to be surface mounted, remove the four small knockouts in the case back. Place two upper #10 screws in the wall spaced according to indicated dimensions in Figure 1. Hang the case on the wall screws. Install two lower screws through the case.

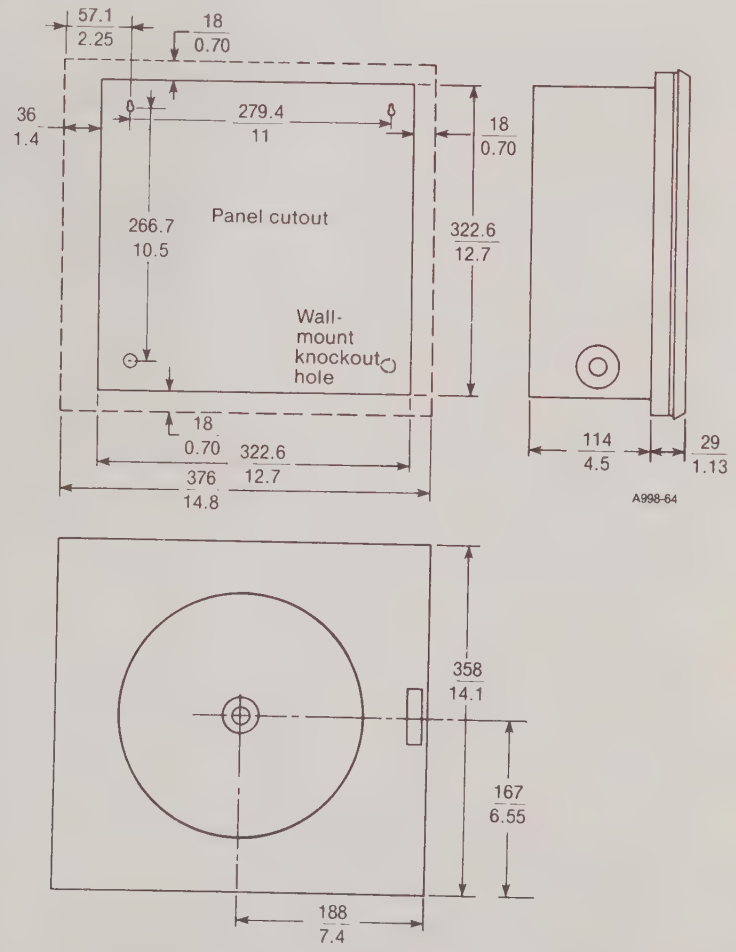
If necessary remove the chart plate to gain maximum access to the back of the case. Loosen the two captive screws at the right side of the plate and swing it open. Unplug connectors from the board(s), disconnect the green ground wire from the back of the chart plate, and lift the plate off its hinges.

Replace the chart plate by refitting the plate onto its hinges, reconnecting the green ground wire to the back of the plate, and re-plugging connectors into the circuit board(s). Connectors are keyed to fit onto only the proper mating locations on the board(s).* Swing the chart plate closed and tighten the 2 captive screws securely into place.

*(Chart drive connector plugs to leftmost or rightmost pair of S_C prongs.)

NOTE: Chart plate screws must be securely tightened. Otherwise the chart may bind against the window tabs and not turn properly.

Dimensions: millimetres / inches



NOTE: Panel cutout hole is off-centered 9 mm (0.35 inches) to the *right* of the overall instrument outline. Measure cutout spacing and panel layout carefully.

Figure 1 – Mounting Dimensions

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Wiring

NOTE: All wiring must comply with local codes, regulations, and ordinances.

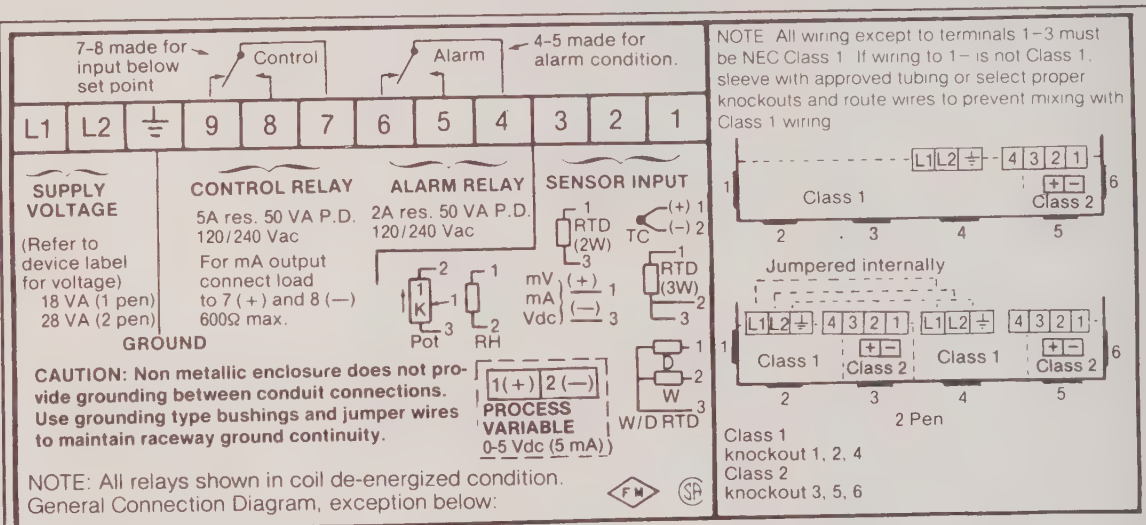
Figures 2 and 3 illustrate typical connections for recorder-controllers and cam programmers. Make connections to the appropriate screw terminals in the controller case as noted in the figure. The supply terminals L1 and L2 are connected between boards 1 and 2 for two-pen models (or single pen models with event switching and/or programming output). Numerals molded in the case identify each channel's circuit board.

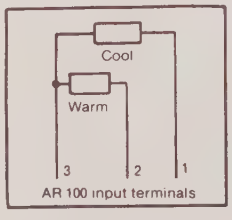
IMPORTANT:
Do not run sensor or low-voltage leadwires in the same conduit with the power line wiring. If metallic raceways are used, grounding type hubs or other means should be used to connect raceways to maintain raceway ground continuity.

Observe polarity when connecting millivolt or thermocouple leadwires. On Honeywell supplied thermocouple leadwires, the negative (−) leadwire always has red insulation (ISA standard). Always use proper extension leadwire and thermocouple for which the unit was calibrated.

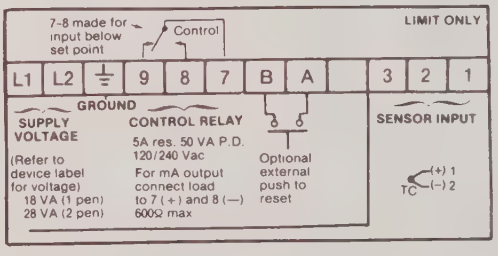
Refer to the specifications for the source resistance and input impedance limitations.

With two-wire RTD (Resistance Temperature Detector) input, minimize leadwire resistance since it adds directly to sensor resistance and necessitates on-site recalibration from the RTD terminals. With a three-wire RTD sensor, use identical leadwire for all three runs to make resistance for all three leadwires equal for optimum leadwire resistance compensation. Insulation on the three RTD sensor leads is generally color coded with the positive lead one color and the two common leads a second color (Figure 4). The positive lead must be connected to terminal 1, and the common leads connected to terminals 2 and 3. In most cases sensor leadwires are less than 150 feet (46 meters) long, allowing the use of 18 gage (1.06mm) copper wire. Longer distances may require heavier gage wire.


7-8 made for input below set point
Control
Alarm
4-5 made for alarm condition.
L1 L2 ⏚ 9 8 7 6 5 4 3 2 1
SUPPLY VOLTAGE
(Refer to device label for voltage)
18 VA (1 pen)
28 VA (2 pen)
GROUND
CONTROL RELAY
5A res. 50 VA P.D.
120/240 Vac
For mA output connect load to 7 (+) and 8 (—) 600Ω max.
ALARM RELAY
2A res. 50 VA P.D.
120/240 Vac
SENSOR INPUT
RTD (2W)
TC
RTD (3W)
mV
mA
Vdc
Pot
RH
W
W/D RTD
CAUTION: Non metallic enclosure does not provide grounding between conduit connections. Use grounding type bushings and jumper wires to maintain raceway ground continuity.
1(+) 2(—)
PROCESS VARIABLE
0-5 Vdc (5 mA)
NOTE: All relays shown in coil de-energized condition.
General Connection Diagram, exception below:
NOTE All wiring except to terminals 1–3 must be NEC Class 1. If wiring to 1– is not Class 1, sleeve with approved tubing or select proper knockouts and route wires to prevent mixing with Class 1 wiring
Class 1
Class 2
Jumpered internally
2 Pen
Class 1 knockout 1, 2, 4
Class 2 knockout 3, 5, 6



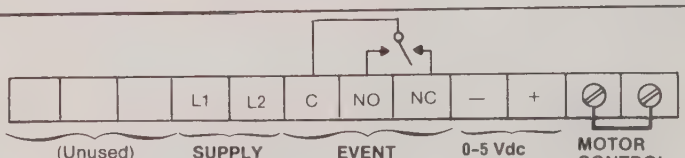
NOTE: Direct Reading Differential Temperature RTD connection (eg. Table VI selection #087).


7-8 made for input below set point
Control
LIMIT ONLY
L1 L2 ⏚ 9 8 7 B A 3 2 1
GROUND
SUPPLY VOLTAGE
(Refer to device label for voltage)
18 VA (1 pen)
28 VA (2 pen)
CONTROL RELAY
5A res. 50 VA P.D.
120/240 Vac
For mA output connect load to 7 (+) and 8 (—) 600Ω max
Optional external push to reset
SENSOR INPUT
TC

NOTE: Manual Reset Limit Control (control form "G" only)

A998-201

Figure 2 – Wiring Connections Diagram for Control Circuit Board


L1 L2 C NO NC — +
(Unused)
SUPPLY VOLTAGE
EVENT RELAY
2A res. 50 VA P.D. 120/240 Vac
0-5 Vdc PROGRAM OUTPUT (remote set point) [5 mA max.]
MOTOR CONTROL (Remove jumper to remove power from chart motor)

NOTE: Relay shown in coil de-energized condition (reflective surface).

A998-125

Figure 3 – Wiring Connections Diagram for cam programmer Event/Program Output Circuit Board

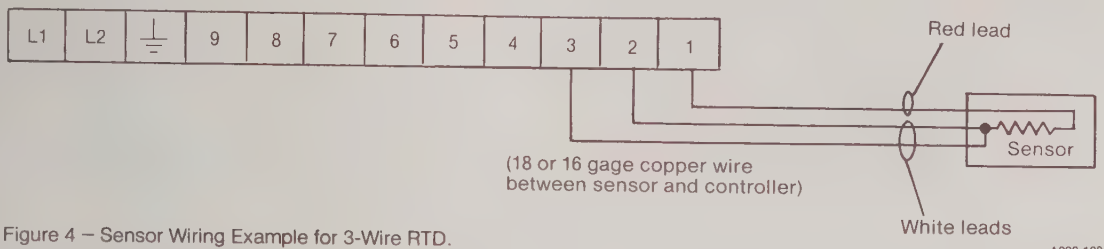


Figure 4 – Sensor Wiring Example for 3-Wire RTD.

Cam Programming

TABLE 1 - Cam Preparation Tools

Plotting	Pencil (or scribe)
	Blank chart (or printed cam blank)
	Square-grid graph paper
	Drawing compass (or scribing compass)
	Cam template (included with instrument)
Cutting	Cam blank*
	Fine-tooth scroll saw
	File or fine sandpaper
	Adhesive**

*Do not remove the protective paper coating from the cam blank until cam is finished.

**Honeywell recommends the use of a commonly available ''rubber cement'' paper adhesive which can be peeled off a surface by rubbing with fingers. If in doubt about an adhesive, test it on an outer edge of the cam blank which will not be part of the final cam.

Program Plotting

Plot the desired program first on graph paper (e.g., Figure 5). Plot the time scale along the horizontal (abscissa) for one full revolution of the cam (depends on chart drive speed). Plot the vertical scale to represent a process variable such as temperature.

This graph establishes sufficient intermediate points to lay out the cam.

Transfer the plotted program to a blank chart using a pencil, or directly onto a printed cam blank using a scribe (stylus). Plot a point for each time division of the chart (e.g., 15 min. per division on a 24 hour chart, or 96 points). Draw a circle, centered at each point, 3/8 inch (9.525 mm) in diameter (Figure 6). Draw (or scribe) a curve tangent to the circles at the point closest to the chart (or cam) center. Compare the rises and falls of this plotted cam pattern with the allowable maximums shown on the template supplied with the instrument. If the rates of change of the plotted pattern exceed the template limits, modify the pattern rises and falls to within those limits.

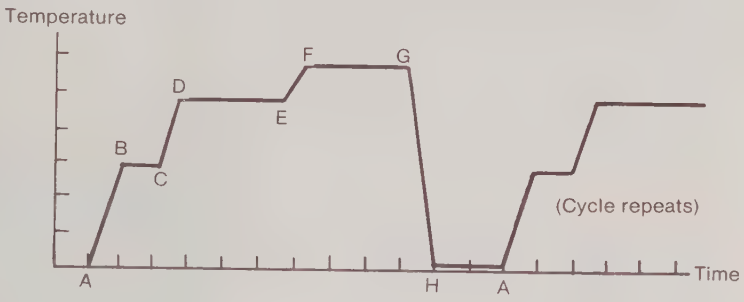


Figure 5 – Process Program Pattern Graph

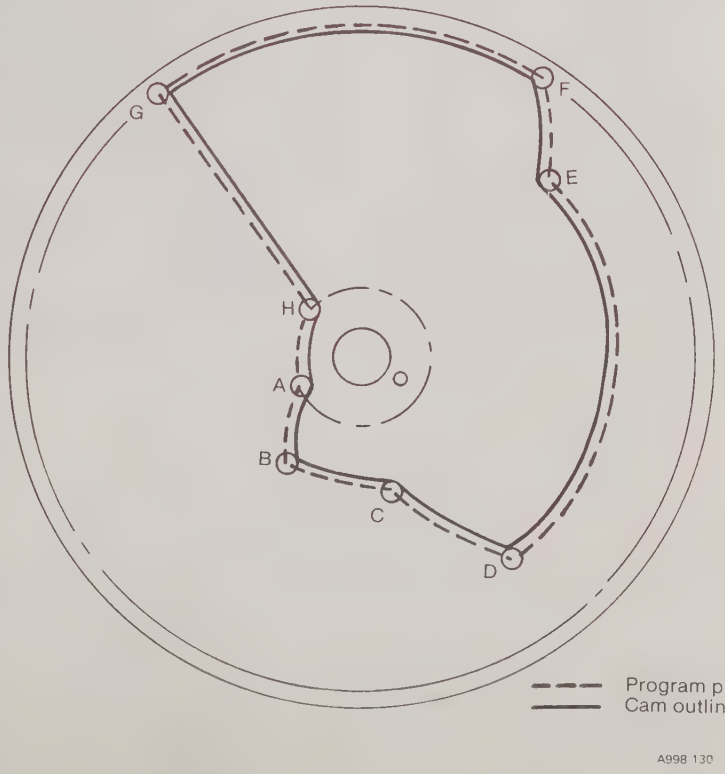


Figure 6 – Cam Pattern Plot on Chart

Cutting the Cam

Cam blanks are made from 0.100 inch (2.54 mm) thick transparent acrylic plastic with an alignment/drive hole in the center.

Apply a non-permanent, semi-tacky adhesive* to the back of the cam-plot paper chart. Align the chart drive hole with the drive groove in the cam blank hole (Figure 7) and attach the paper chart to the paper coating on the cam blank. Cut along the pattern line using a finetooth scroll saw. Smooth the edges of the cam with a file or fine sandpaper. Remove the pattern chart paper and the protective coating paper from the cam, as well as any remaining adhesive.

*CAUTION: Remove rubber cement or other adhesive from acrylic cam as soon as cam is cut and finished. Solvents in adhesive can deteriorate the plastic surface if left on longer than needed to cut the cam.

Attaching the Cam

NOTE: A chart must be installed *before* attaching the cam.

Swing the spring-loaded cam follower arm clear of the cam area and tighten its small knurled holding nut to fasten it in position. Remove the large knurled nut from the chart/cam drive hub. Position the cam on the drive hub, aligning the groove in the cam hole with the matching alignment key on the drive hub. Replace the large knurled nut on the hub and tighten securely. Hold the cam follower arm and loosen its knurled holding nut to allow the arm to move freely. Swing the follower arm gently back to the cam so that the cam roller on the end of the follower arm rests on the edge of the cam.

Cleaning

Clean the case and with a common household-strength liquid detergent or ammonia-and-water solution.

CAUTION: Do not clean with halogenated or aromatic hydrocarbons (cleaning oils). They can deteriorate the plastic surfaces.

Clean the glass or plastic window (and the plastic cam of appropriate models) with a soft cloth and an ammonia-and-water solution (household-strength window cleaner).

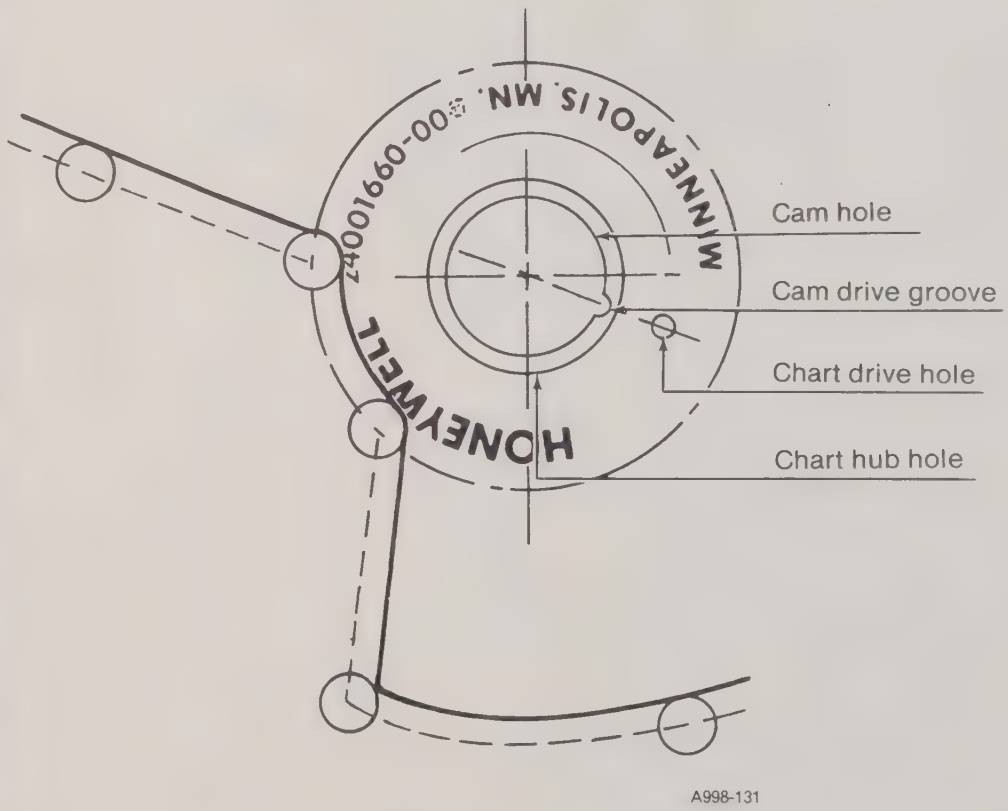


Figure 7 – Alignment of Cam and Chart Holes

Series AR 100 Recorder-Controller and Cam Programmer

Operating Data

Introduction

This section contains instructions for the startup and operational maintenance of Honeywell's Series AR 100 Recorder–Controllers and Cam Programmers: adjustments to tune the controller to fit process requirements, and procedures to replace "consumable" items such as pen cartridges and charts (Figures 1, 2). Paragraph headings direct the reader to information applicable to a particular model, since no one instrument can embody all the operations described. Compare the model number of a particular instrument with the interpretation tables in the Model Selection Guide(s) to determine what control features the model includes.

[The model number is listed on a label on the front of the chart plate, under the chart paper, toward the lower left side.]

Chart Changing

NOTE: As a chart is removed or replaced, gently hold the pen(s) away from the chart face to avoid undesirable markings resulting from the pen(s) dragging across the chart surface. If pen cartridges also require replacement, remove old cartridges before replacing chart (Step 2 of "Pen Cartridge Replacement), and install new cartridges after new chart is in place.

1. Press at bottom of latching lever at the right side of the door and pull door open. [Remove the cam from cam program models (Figure 2) to replace a chart.]
2. Gently lift and peel chart away from chart plate, from left to right, while gently lifting pen(s) away from the chart.
3. Place a new chart on the chart plate with the centrol hole over the chart hub and the smaller alignment hole over the small drive pin.
4. Adjust the time setting of the chart by holding the chart hub and drive pin and twisting clockwise as needed to align the chart with the desired time line at the point of the #1 pen.
5. Close door.

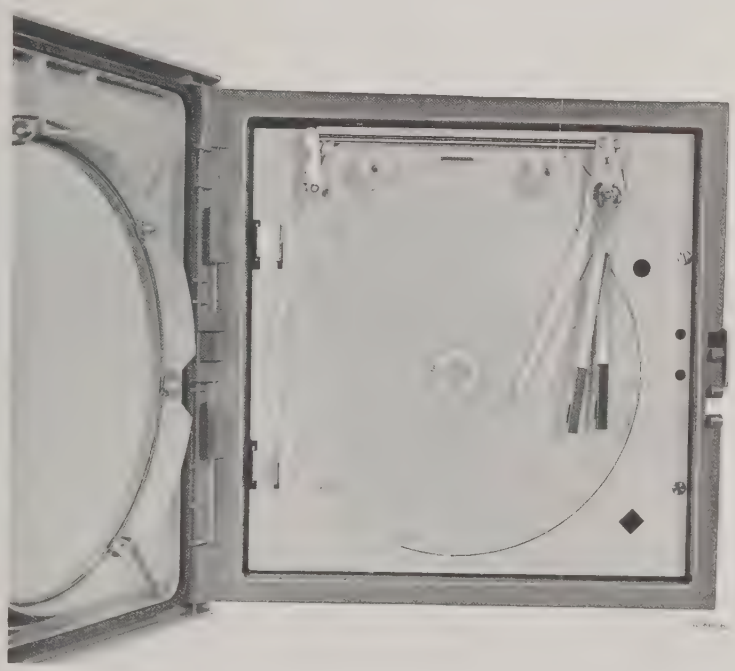


Figure 1 – Two-Pen Unit, door open for chart or pen cartridge replacement

Pen Cartridge Replacement

When the pen trace becomes undesirably faint, replace the pen cartridge as follows:

1. Open recorder door. [Remove the cam from cam program models (Figure 2) to replace a pen cartridge.]
2. Slide old cartridge down off pen arm.

   NOTE: If also changing chart, do so before step 3.
3. Position a new cartridge along pen arm with pen hub against V-notch at end of arm.
4. Close clasp around pen arm and snap it into place on cartridge body.
5. Remove plastic pen tip cap, taking care not let fingers touch the exposed tip. (Oil from fingertips may deteriorate pen performance)

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Cam Removal

Several operations require removal of the cam for access.* With the case door open, refer to Figure 2 and:

1. Swing spring-loaded cam follower arm (#1) clear of the cam area and tighten the knurled holding nut (#2) to fasten the arm in position.*
2. Remove the large knurled nut (#3) from the cam/chart drive hub.
3. Remove the cam (#4) from the hub. Perform required operations and replace the cam.

*If this must be done while the instrument continues running, begin by tightening the small knurled nut to fasten the arm in position at the cam edge setting.

Cam Replacement

To replace a cam, refer to Figure 2 and:

1. With the large knurled nut from the cam/chart drive hub (#3) removed, and the spring-loaded cam follower arm (#1) held clear of the cam area by the small knurled nut (#2), position the cam (#4) on the drive hub with the groove in the cam hole aligned to the matching key on the drive hub.
2. Replace the large knurled nut on the hub and tighten securely.
3. Hold the cam follower arm and loosen its knurled holding nut to allow the arm to move freely.
4. Swing the follower arm gently back to the cam so that the cam roller on the end of the follower arm rests on the edge of the cam.

Adjustments

Recording and set point (or cam) adjustments are accessible with the chart-plate in place (Figures 2, 3). The manual reset potentiometer(s) on proportional control models can be adjusted through the holes in the right side of the chart plate or with the chart plate open for access (Figures 4, 5).

Chart Time (Figure 3)

Rotate chart drive hub (#1) clockwise to set time. (On cam models, turn cam manually or remove cam to rotate drive hub). Align desired time line on chart with reference mark on chart plate (#2).

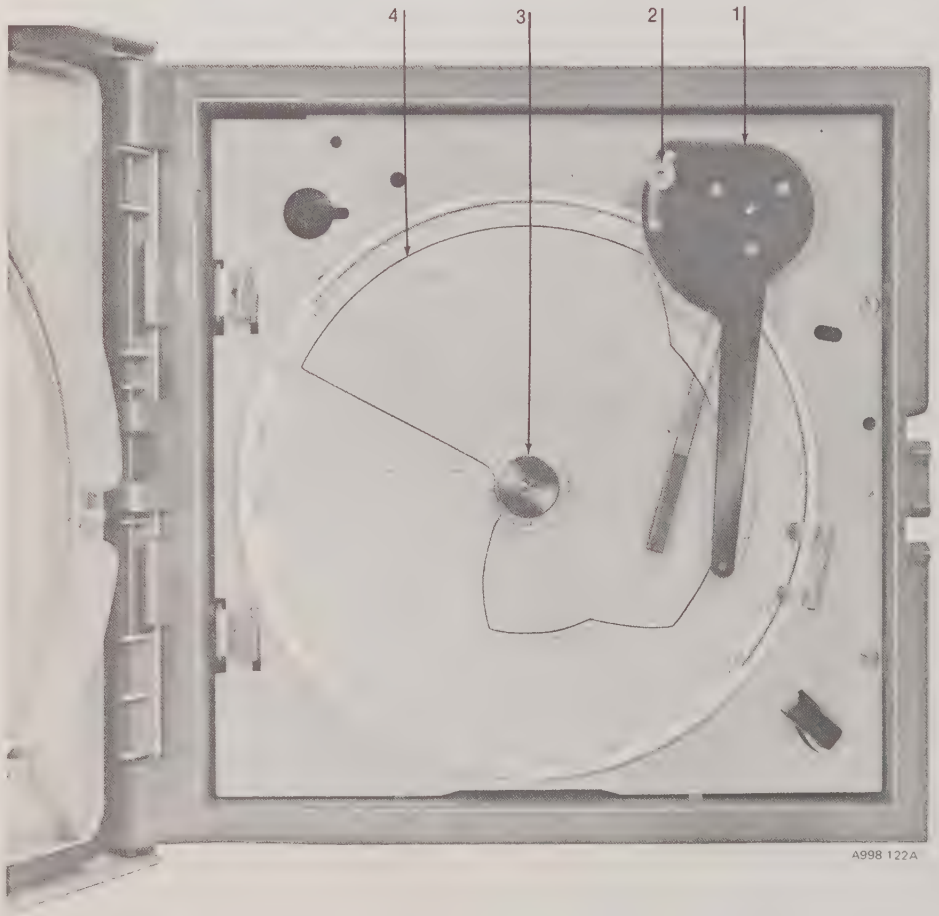

Figure 2 – Cam Programmer model, Front adjustments view.

Controller Set Point(s) (Figure 3)

Rotate appropriate set point knob to position set point index to desired point on chart. On two-pen models the No. 1 set point is on the right (#4) with No. 2 on the left (#5). The No. 1 index is located closest to chart surface. The No. 2 set point index and knob are color-keyed with the No. 2 pen color.

Cam Program models control the set point as a spring-loaded follower arm (Figure 2, #1) is positioned by cam displacement. These models can be operated ***without a cam*** by manually positioning the follower arm and tightening its small knurled holding nut (Figure 2, #2) to fasten the arm in position. Position the follower arm so that the center point of the roller at the end of the arm indicates the desired set point. Position the large knurled nut (Figure 2, #3) on its center coupling (flat surface outward, relieved surface toward the chart plate) and tighten securely to lock the drive hub without a cam.

Manual Reset

Proportional control models are potentiometer-adjusted to shift the proportional control band upscale or downscale with respect to the set point index. On 2-pen units, the No. 2 reset potentiometer is located above the No. 1 potentiometer (Figure 3, #3). The purpose of this adjustment is to overcome "offset" or "droop" as manifested by a continuing difference between the set point index position and the pen trace. The adjustment technique is described in Figure 13.

Chart Plate Opening

Loosen 2 captive chart plate retaining screws and swing chart plate out for access to electronic adjustments on the circuit board(s).

General Note:

No. 1 Printed Circuit Board on right
No. 2 Printed Circuit Board on left
Controllers are factory calibrated to a specific range and sensor actuation before shipment. Recalibration procedures are included in the Service section of the manual, along with range changing and sensor actuation changing information.

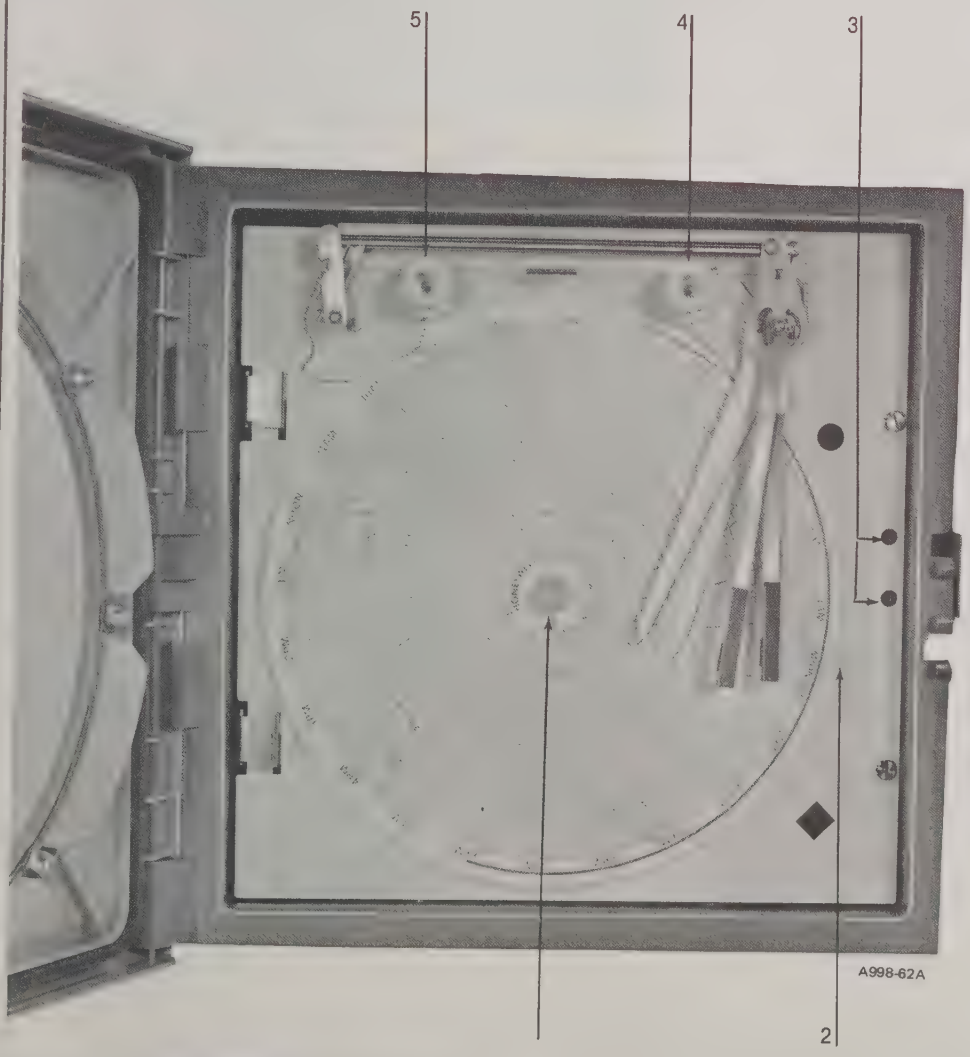

Figure 3 – Recorder-Controller front set adjustments.

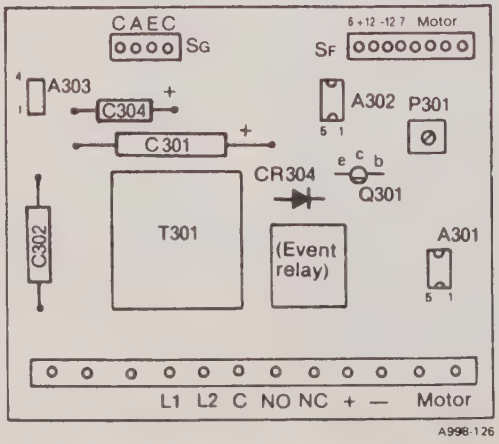

Figure 5 – Event switching/programming output board

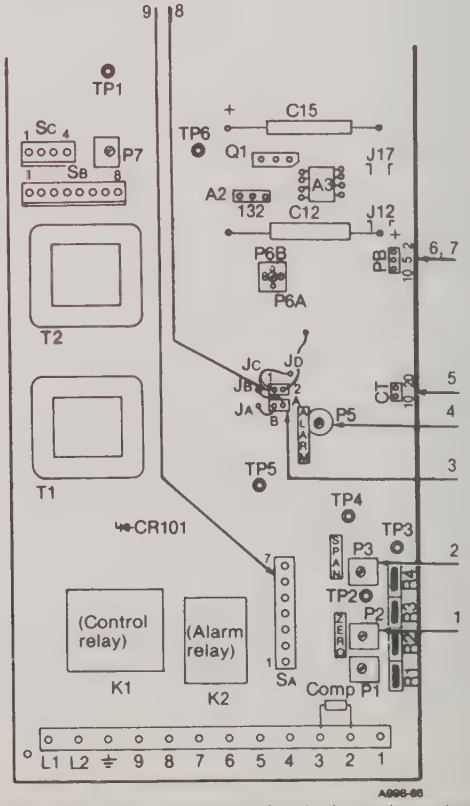

Figure 4 – Typical tuning adjustments for single mode controller

Span and Zero Adjustment

Input span and zero adjustments are electrical and are available to compensate for sensor variations and to perform system calibration.

- Pot P2 (labelled zero, Figure 4, #1) provides the zero adjustment. Clockwise rotation makes pen write at a higher chart value.
- Pot P3 (labelled span, Figure 4, #2) adjusts the span. Clockwise rotation increases the span, that is, a greater input signal span is required to cover from 0 to 100% of the chart.

Alarm Set Point

Alarm Mode Selection

- The alarm is shipped in the high alarm mode, (i.e., alarm relay is energized when the input signal level exceeds the alarm set point). The alarm can be converted to a low alarm by interchanging jumpers (Figure 4, #3):

  Jumper A on Post B and Jumper B on Post A sets to high alarm mode.

  Jumper A on Post A and Jumper B on Post B sets to low alarm mode.
- Adjust P5 (labelled alarm, Figure 4, #4) to give the desired alarm setting. P5 is a 4.5 turn pot with full clockwise rotation giving the maximum alarm setting. The alarm can be set corresponding to any level over the range of the device. With an adjustable simulated input, adjust input to drive pen to desired alarm set point.* Adjust P5 to make alarm relay operate at this level. Check by reducing input and increasing slowly until alarm relay operates. Pen position at which relay operates is the alarm setting.

Time Proportioning Output

- **Cycle Time**
  The cycle time can be set to either 10 or 20 seconds by moving a plug-on jumper. (CT, Figure 4, #5)
- **Proportional Band**
  The single mode proportional band can be set to 2, 5 or 10% of span by moving a plug-on jumper. (PB, Figure 4, #6)

  On 3-mode controllers, the plug on jumper remains in the "2%" position and proportional band can be adjusted from 1% to 100% of span by setting a potentiometer (P401, Figure 6).

*An approximate alarm set point can be obtained without a simulated input signal. Turn P5 fully counterclockwise (i.e., at least 5 turns), then 1/2 turn clockwise. The alarm setting will be at 0% of span. Each successive full turn clockwise will increase the setting by 25% of the span.

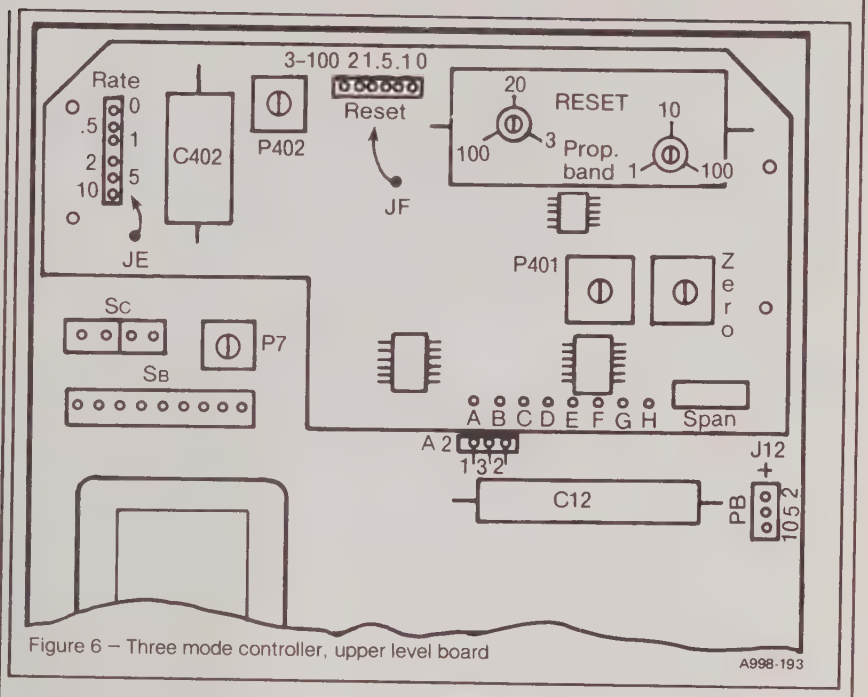

Figure 6 – Three mode controller, upper level board

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- **Reset (Integral)**
  On 3-mode controllers, settings of 0, 0.1, 0.5, 1, or 2 repeats per minute can be made by moving a plug-on jumper (JF, Figure 6). An additional jumper position selects a potentiometer (P402) to allow adjustment from 3 to 100 repeats per minute.
- **Rate (Derivative)**
  On 3-mode controllers, settings of 0, 0.5, 1, 2, 5, or 10 minutes can be selected by moving a plug-on jumper (Figure 6, JE).

Current Proportioning Output

- **Proportional Band**
  The single mode proportional band can be set to 2, 5 or 10% of span by moving a plug-on jumper. (PB, Figure 4, #7)

  On 3-mode controllers, the plug on jumper remains in the "2%" position and proportional band can be adjusted from 1% to 100% of span by setting a potentiometer (P104, Figure 6).
- **Reset (Integral)**
  On 3-mode controllers, settings of 0, 0.1, 0.5, 1, or 2 repeats per minute can be made by moving a plug-on jumper (JF, Figure 6). An additional jumper position selects a potentiometer (P402) to allow adjustment from 3 to 100 repeats per minute.
- **Rate (Derivative)**
  On 3-mode controllers, settings of 0, 0.5, 1, 2, 5, or 10 minutes can be selected by moving a plug-on jumper (Figure 6, JE).
- **Mode**
  The unit is shipped with the current output/input operating in an inverse relationship. (Output current decreases for increasing input.) The mode can be changed to direct acting by interchanging jumpers (Figure 4, #8):

  Jumper C on Post 1 and Jumper D on Post 2 sets to inverse mode (as PV signal increases, 4 to 20 mA current output decreases).

  Jumper C on Post 2 and Jumper D on Post 1 sets to direct mode (as PV signal increases, 4 to 20 mA current output increases).

Burnout Reversal

- The sensor break protection is normally set to drive upscale. Remove the 100 megohm resistor from posts 2 and 5 of the SA connector post assembly (Figure 4, #9) and replace onto posts 2 and 3 to provide downscale drive (thermocouple models only).

Event Switching

A relay on the smaller No. 2 circuit board (Figure 5, on single-pen or cam program models so equipped) is de-energized whenever there is a reflective surface over the optical sensor, that is, when the white back of a chart covers the chart plate hole where the sensor is mounted. A non-reflective surface such as a flat black paper tape or vinyl electrical tape energizes the relay to close.

Prepare an event triggering chart as follows:

1. Draw a radial line on the face of a blank chart (Figure 7). For example, to trigger the relay at 3AM on a 24 hour chart: Set a straight-edge on the face of the chart to draw a line through the 3AM point at the chart scale maximum to the similar 3PM point at the opposite side of the chart. Draw the line dark enough to be visible through the chart paper from the back of the chart.
2. Affix a piece of black tape to the back of the chart paper along that line at the outer edge at the 3AM position as shown. The tape must cover a minimum area 1/2 inch (13mm) along the line from the outer edge and 1/4 inch (7 mm) along the edge from the radial line image toward 4AM (i.e., toward later time positions of the chart).

If more than one activation of the relay is desired within a given chart cycle, an event may be triggered again with another piece of tape soon after the relay de-energizes. (The duration of relay closure is approximately 1% of the chart circumference, or 14 minutes on a 24 hour chart.)

This chart may be re-used for event triggering in more than one cycle of the process. Place another chart over the event chart for recording pen traces, and change only that chart after each cycle, leaving the event chart in place.

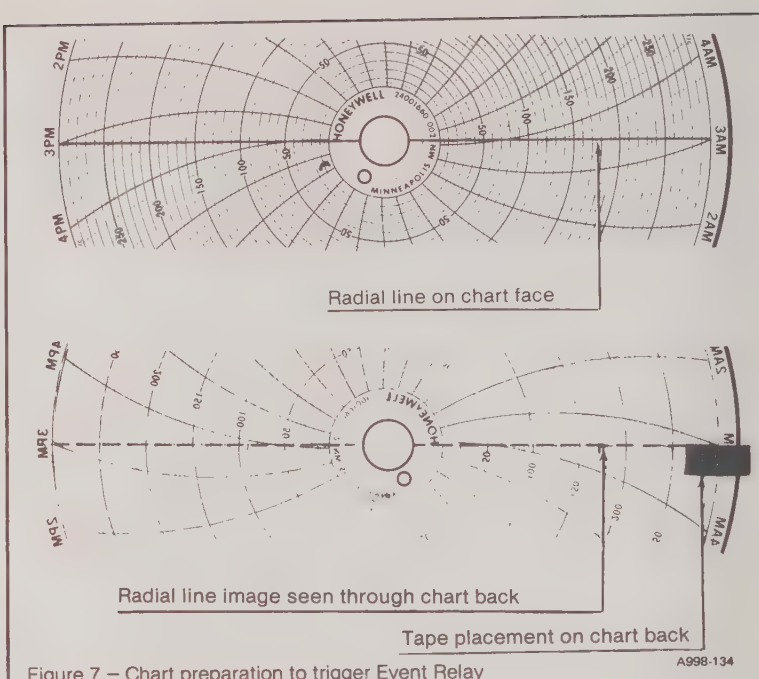


Figure 7 – Chart preparation to trigger Event Relay

Programming Output

The 0 to 5 Vdc programming output provides a remote set point signal to other controllers. The output is factory adjusted to be zero when the cam follower is at zero. The output when the cam follower is at maximum is nominally 5 volts (plus or minus the millivoltage tolerance of the set point signal).

Dialapak controllers accept the remote set point programming output through an adaptor card (part number 24110258-002, 0 to 5 volts). The signal span is trimmed (adjusted) with a potentiometer on the adaptor card.

DialaTrol controllers accept the remote set point programming output through an adaptor card (part number 138861C). The signal span is trimmed at the adaptor card. If the DialaTrol controller span is over 25 mV, clip out R6 (188 ohms).

High Limit

The limit control is a high or low cutoff control that requires a manual operation to close or reset the relay.

Manual reset (Figure 8) is required on initial start-up. A red light behind the chart paper indicates the relay is open.

The unit can be converted to low limit control by reversing jumpers JA and JB located on the right center portion of the PWB (Figure 10). If the unit is converted to low limit, the burnout protection can be changed to downscale as in the standard recorder (posts 2 and 3 of connector SA). See Figure 10.

Potentiometer P301 can be used to calibrate the relay dropout point to the set point.

An optional plug-in board (Figure 9) is available to reset the control relay automatically on initial start-up or after power failure.

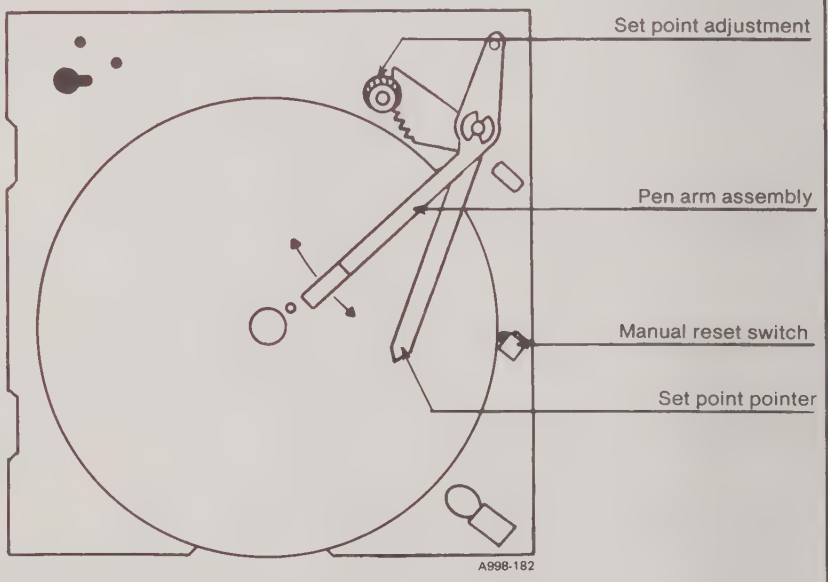
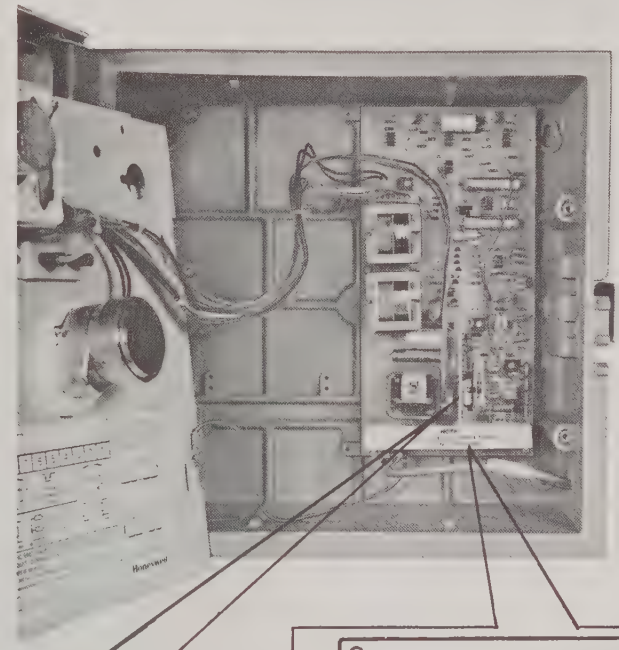


Figure 8 – Manual Reset Switch and Set Point Adjustments

High Limit Relay Calibration

1. Adjust the input until the pen is aligned with the set point (Figure 8).
2. Hold the manual reset switch down (Figure 8).
3. Adjust potentiometer P301 until the relay just drops out (Figure 10).



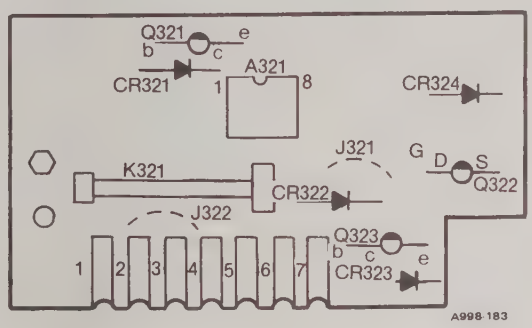


Figure 9 – Auto-Reset Circuit Board #24400131-001
Plugs into Connector SE (Limit Control option)

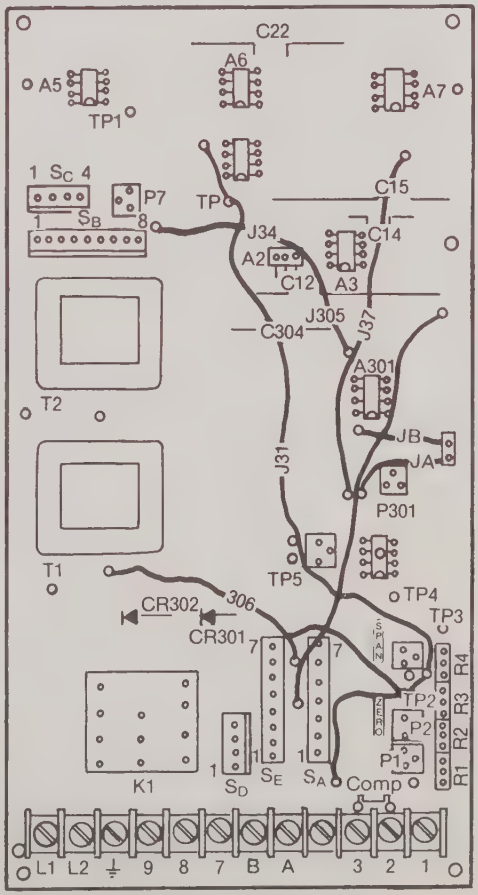


Figure 10 – Typical Tuning Adjustments.
AR100 with High/Low Limit Control.

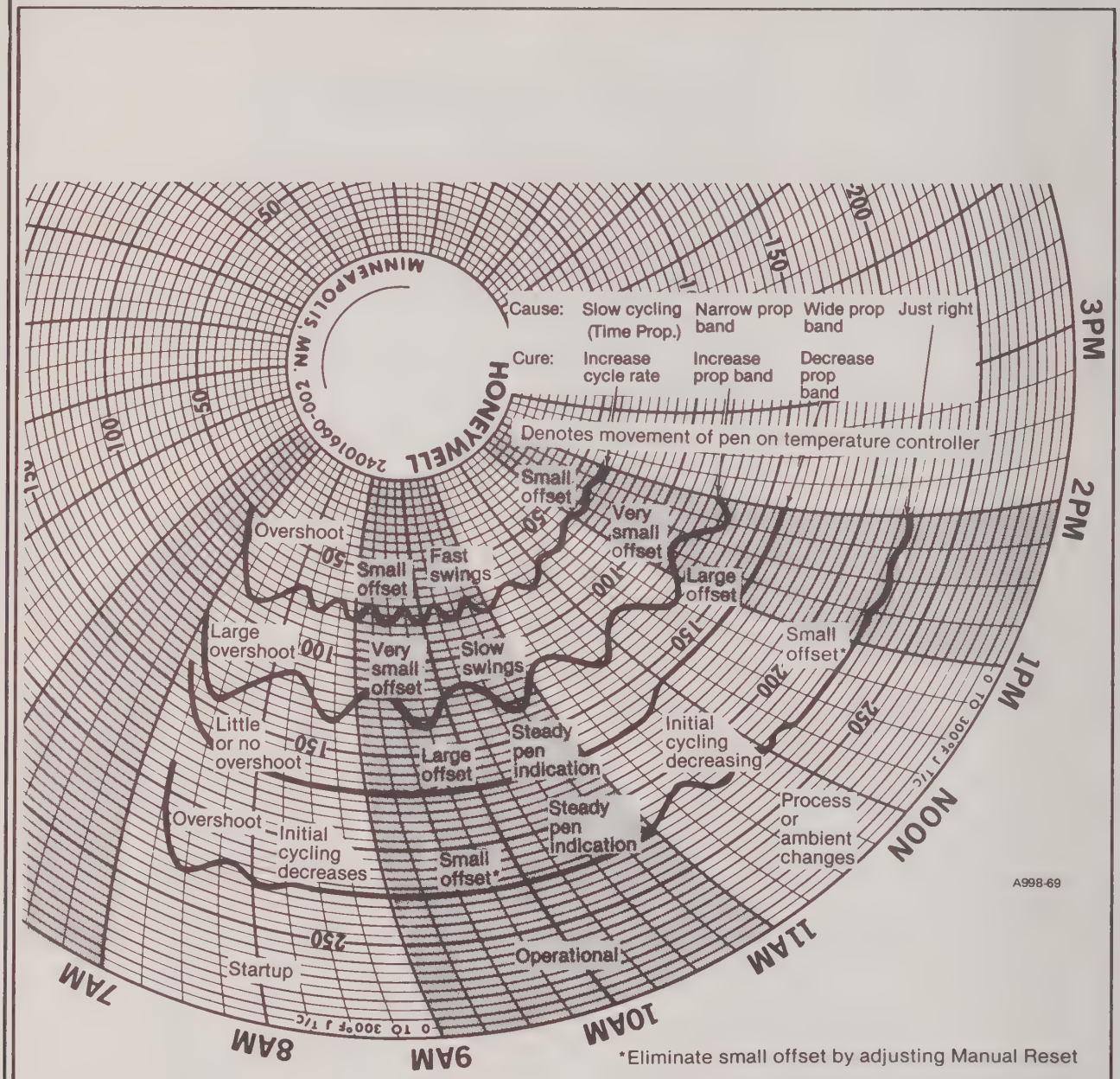


Figure 11 – Using pen trace on 1-mode proportional controller as guide to tuning adjustments required.

Startup

Turn the instrument on, and make sure the alarm set point, controller set point, and chart time adjustments are set as desired. (Refer to the "Adjustments" paragraphs as needed.)

NOTE: Make provisions to bypass the alarm if process condition exceeds alarm set point at startup and the alarm contacts are wired to shut down power to the load.

Remember that chart plate retaining screws must be tight, when the case door is latched closed, so that chart paper does not bind against window tabs on the door.

Tuning Single Mode Proportional Controllers

After startup, with control and alarm (if applicable) set points established, observe pen traces to determine what proportional band or cycle time adjustments are necessary for optimum control action. Figure 11 shows portions of typical traces and gives the cause and a "cure" (adjustment) applicable to the trace. Make tuning adjustments based on the sample traces in Figure 11 or the adjustment diagrams (Figures 12, 13, and 14).

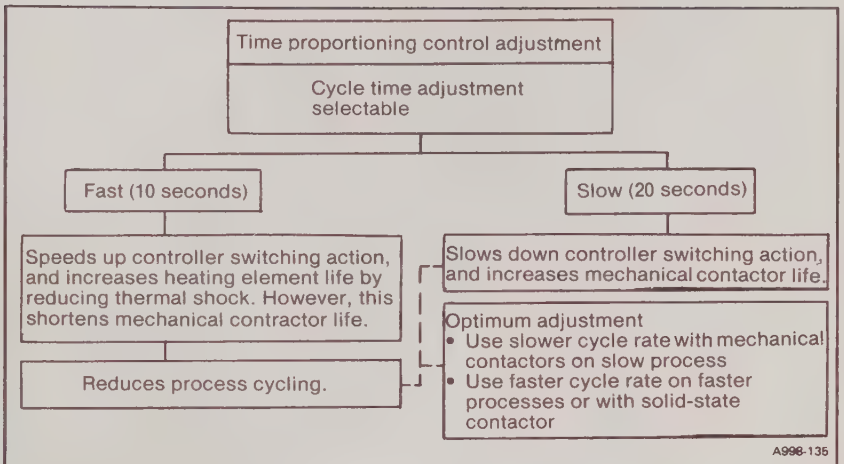

Time proportioning control adjustment
Cycle time adjustment selectable
Fast (10 seconds)
Slow (20 seconds)
Speeds up controller switching action, and increases heating element life by reducing thermal shock. However, this shortens mechanical contractor life.
Slows down controller switching action, and increases mechanical contactor life.
Reduces process cycling.
Optimum adjustment
• Use slower cycle rate with mechanical contactors on slow process
• Use faster cycle rate on faster processes or with solid-state contactor
A998-135

Figure 12 – Time Proportioning cycle time adjustments.

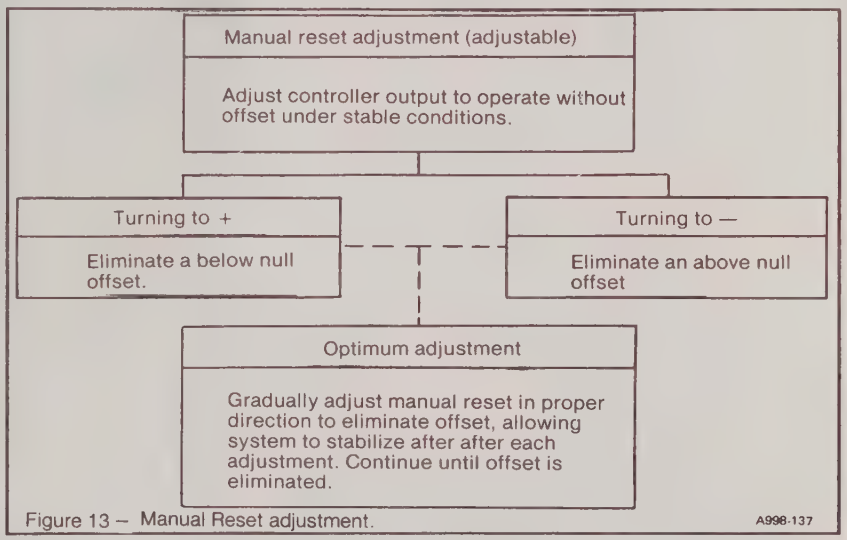

Manual reset adjustment (adjustable)
Adjust controller output to operate without offset under stable conditions.
Turning to +
Eliminate a below null offset.
Turning to —
Eliminate an above null offset
Optimum adjustment
Gradually adjust manual reset in proper direction to eliminate offset, allowing system to stabilize after after each adjustment. Continue until offset is eliminated.
A998-137

Figure 13 – Manual Reset adjustment.

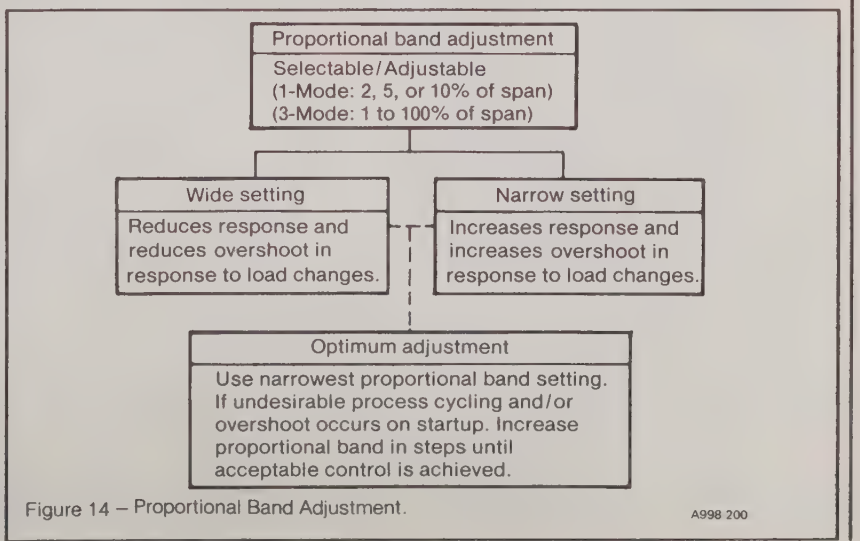

Proportional band adjustment
Selectable/Adjustable
(1-Mode: 2, 5, or 10% of span)
(3-Mode: 1 to 100% of span)
Wide setting
Reduces response and reduces overshoot in response to load changes.
Narrow setting
Increases response and increases overshoot in response to load changes.
Optimum adjustment
Use narrowest proportional band setting. If undesirable process cycling and/or overshoot occurs on startup. Increase proportional band in steps until acceptable control is achieved.
A998-200

Figure 14 – Proportional Band Adjustment.

Three Modes of Control: Proportional Band, Reset, Rate

Proportional Band *(PB) is a percentage of the instrument span, within the control output changes in proportion to the difference between the Process Variable (PV) and the Set Point (SP). As PB is increased, the less the output changes for a given PV change. For example: With the PB set to 10% of span, if the PV deviates 2% from the SP (i.e., 2/10 the PB range), the output changes by 2/10 of the possible output range. Assume when PV = SP, the output is at 1/2 (50%). For a +2% deviation (and reverse output action) PB subtracts 2/10 of the output range (2% PV change/10%PB = 2/10 =20%) and the output becomes 3/10 (30%). (1/2initial−2/10PB = 3/10 = 30%).*

For a −2% deviation (and reverse action) PB adds 2/10 to the output value and the output becomes 7/10 (70%). (1/2initial + 2/10PB = 7/10 = 70%). If for some reason the PV remains 2% away from the SP, nothing will change that output strength to correct the deviation except some additional control mode.

Reset *(repeats per minute) refers to a change in the output level over a period of time, in addition to the effect due to the PB action. Reset action adds to the output some portion of the PB output value each minute. If the Reset setting is 0.5, in one minute the additional output change will be half the change caused by PB effect. In our example of a −2% deviation (and reverse action), PB added 2/10 to the output value. One minute of Reset change adds another 1/10. (0.5R/M X 2/10added(PB) = 1/10), increasing the output value to 8/10 (1/2initial + 2/10PB + 1/101 min. Reset = 8/10 = 80%).*

If the PV deviation is still −2%, the output will reach maximum in another two minutes and can go no further. (Protective reset lockout circuitry prevents the controller from overdriving the final control element.) Now, if suddenly the PV returns to the SP level, the PB portion of the output (2/10) disappears, but the 3/10 portion due to reset action will remain until there is another PV deviation change.

Rate *action also adds to the output level, depending on how fast the PV is changing from the SP. The additional output is applied only while the error (PV−SP) is changing. There is no rate action, even if the PV is 20% off the SP, (i.e., outside the PB range), unless the error in increasing or decreasing. Rate action immediately changes the output as much as PB would in a given number of minutes. For example: If the PV gradually moves to 2% below the SP in 2 minutes, the output takes 2 minutes to reach the 7/10 level (due to the added 2/10PB as before). A rate setting of 2 minutes immediately increases the output from 1/2 to 7/10, and the output continues gradually to increase another 2/10 in 2 minutes due to PB action (1/2initial + 2/10rate action + 2/10PB = 9/10 = 90%).*
If the PV stops at the −2% deviation after 2 minutes, the rate addition disappears and the output returns to the 7/10 level produced by PB action. A rate setting of 1 minute would have immediately increased the output by 1/10 (half the 2-minute PB effect), and after 2 minutes the output would have been 8/10 (1/2initial + 1/10rate action + 2/10PB = 8/10 = 80%), dropping back to 7/10 when the rate addition disappeared.

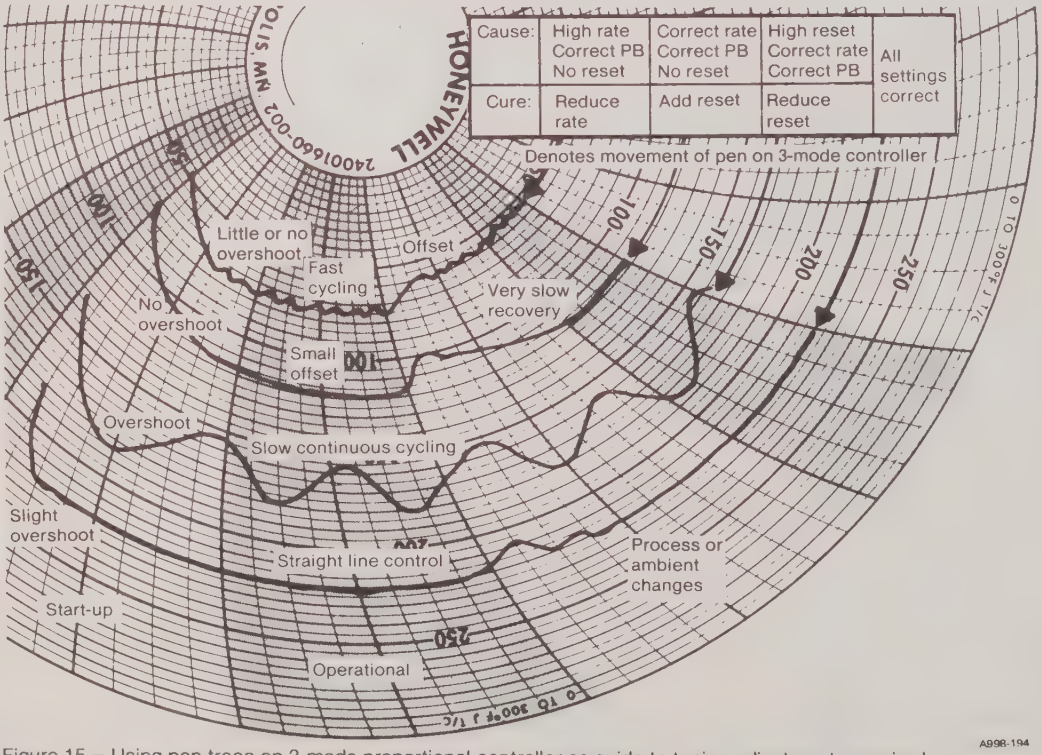


Figure 15 – Using pen trace on 3-mode proportional controller as guide to tuning adjustments required

Tuning Three Mode Proportional Controllers

After startup, with control and alarm (if applicable) set points established, observe pen traces while performing the following steps:

Time Proportioning Only

Refer to Figures 11 and 12 to determine correct cycle time adjustment.

Time and Current Proportioning

1. Set reset and rate plug-on jumpers each to the zero (''0'') position.
2. Adjust the proportional band potentioemter P401 to a high setting, then reduce the setting until the process begins cycling. Note how much time per complete cycle (time between peaks).
3. Adjust P401 to 100%.
4. Move the reset jumper to increase the reset repeats per minuts until the process begins cycling. Note how much time per complete cycle (time between peaks).

   Generally, the cycling time due to too much reset is longer than the cycling time due to a too narrow PB. This permits identification of which action must be changed to correct the control action.
5. Tune the controller for optimum balance of reset and PB (minimal cycling).
6. Determine the reset time from the reset repeats per minute. Reset Time = 1/(repeats per minute) = minutes (per repeat).
7. Move the rate jumper to the setting nearest to the value of one-fourth of the reset time.
8. Change the SP slightly (to ''bump'' the process).
9. If the PV trace on the chart overshoots the SP before settling to the new value, increase the rate setting. If the PV trace on the chart undershoots the SP before settling to the new value, decrease the rate setting. Choose the rate setting which permits the minimum deviation from SP due to either overshoot or undershoot.
10. Return the SP (changed in step 8) to the desired value and observe the chart trace.

Additional changes in the tuning should be made in accordance with sample trace indications in Figure 15 or the adjustment diagrams (Figures 16 and 17).

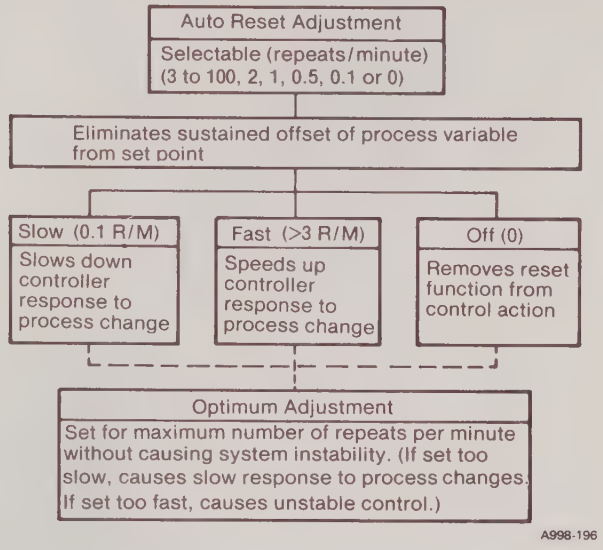

Auto Reset Adjustment
Selectable (repeats/minute)
(3 to 100, 2, 1, 0.5, 0.1 or 0)
Eliminates sustained offset of process variable from set point
Slow (0.1 R/M)
Slows down controller response to process change
Fast (>3 R/M)
Speeds up controller response to process change
Off (0)
Removes reset function from control action
Optimum Adjustment
Set for maximum number of repeats per minute without causing system instability. (If set too slow, causes slow response to process changes. If set too fast, causes unstable control.)
A998-196

Figure 16 – Auto Reset Adjustment

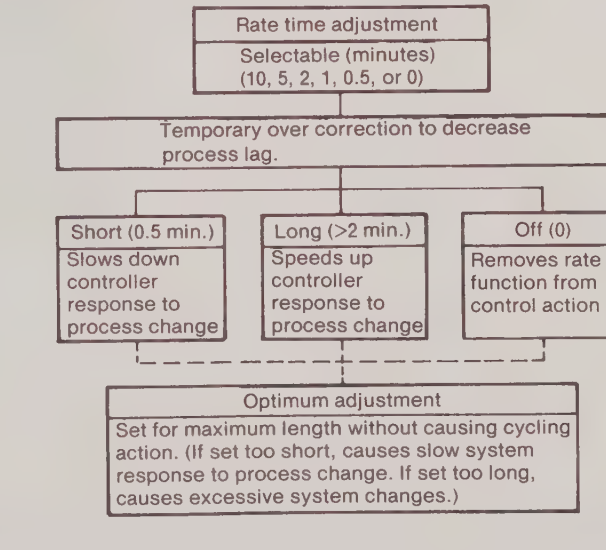

Rate time adjustment
Selectable (minutes)
(10, 5, 2, 1, 0.5, or 0)
Temporary over correction to decrease process lag.
Short (0.5 min.)
Slows down controller response to process change
Long (>2 min.)
Speeds up controller response to process change
Off (0)
Removes rate function from control action
Optimum adjustment
Set for maximum length without causing cycling action. (If set too short, causes slow system response to process change. If set too long, causes excessive system changes.)
A998-197

Figure 17 – Rate Time Adjustment

Cleaning

Clean the case door occasionally with a common household-strength liquid detergent or ammonia-and-water solution.

CAUTION: Do not clean with halogenated or aromatic hydrocarbons (cleaning oils). They can deteriorate the plastic surfaces.

Clean the glass or plastic window (and the plastic cam of appropriate models) with a soft cloth and an ammonia-and-water solution (household-strength window cleaner).

If the case develops a static charge which tends to attract and collect dust and dirt:

1. Clean the case and window.
2. Apply an anti-static solution such as ''Statnul''* or equivalent.

*''Statnul'' manufactured by Weston Instruments, Inc. (Spec. no. 630, Model 9014) 614 Frelinghuysen Ave., Newark, NJ 07114.

Series AR100 Recorder-Controller and Cam Programmer

Service Data

Introduction

This section contains instructions for the calibration and servicing of Honeywell's Series AR100 Recorder-Controllers and Cam Programmers: conversion to different ranges and sensor actuations, calibration methods for various sensor inputs, troubleshooting, and overall schematic diagrams of the instrument.

Range Changing*

Within the capabilities of a particular sensor type, range changing is accomplished by changing four thick-film ceramic resistors R1, R2, R3, and R4 in slot sockets at the lower right side of the controller board (Figure 1). Consult Table 1 to determine the correct resistors for the desired range and sensor.

CAUTION:

The unit is conditioned for one particular sensor type. If a different sensor is desired, consult the "Sensor/Actuation Changing" paragraph.

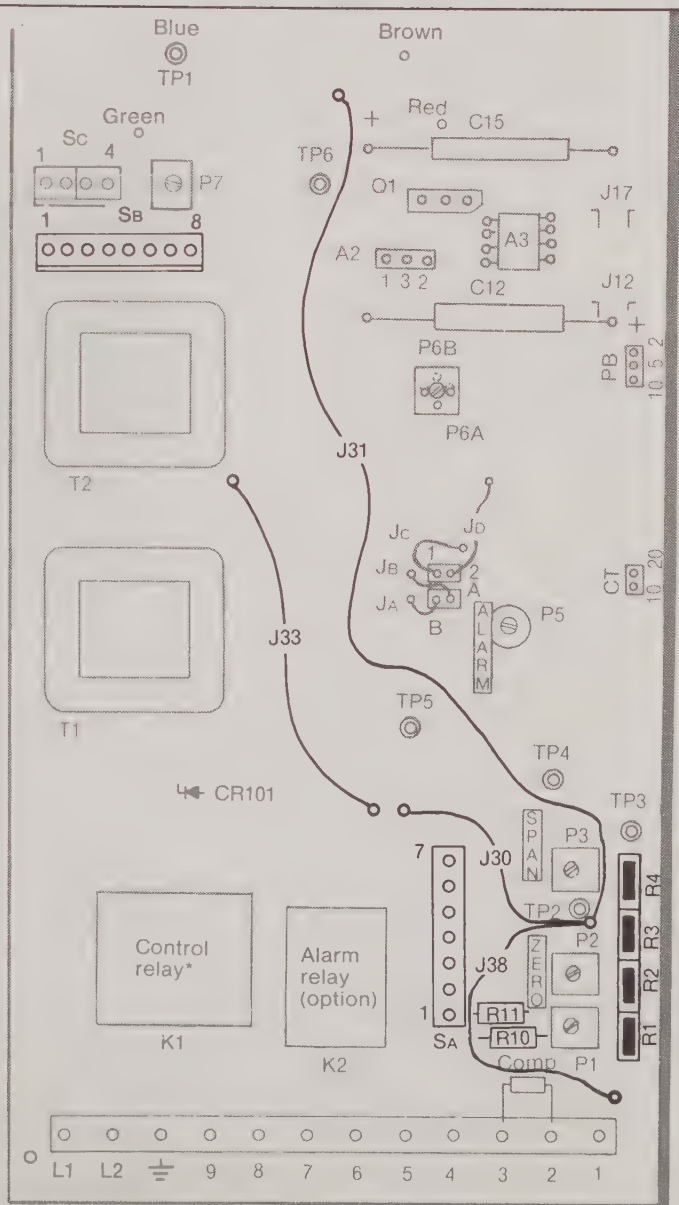
Replacement boards are initially configured for thermocouple actuation. Reconfigure the fixed jumpers and resistors for other sensors as needed (Table 2).

Resistors must be plugged into sockets with the printed metal resistor pattern facing toward the right, or outer edge, of the board with contact areas plugged into sockets first.

Sensor/Actuation Changing*

Consult Table 2 to determine correct sensor signal conditioning components and component positioning on connector SA on the controller board (Figure 1). Plug components onto the indicated SA connector posts for the desired sensor.

*NOTE: Recalibrate the instrument after any range or sensor change. Write all changes (and other pertinent data) on the label on the chart plate front: new range, new actuation (sensor type), date of conversion/recalibration, service technician's initials, etc.



*(Used only on 2-position and time proportioning controllers)
NOTE: Current Proportioning Mode jumpers (J_C & J_D) are shown in Inverse Mode position. Alarm mode jumpers (J_A & J_B) are shown in High Alarm position.

A998-66-2

Figure 1 – Controller Board (major components shown)

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TABLE 1 – Range Change Components

Range	Sensor Type	R1	R2	R3	R4
0-250°F	E	24001651-657 (6.57K)	24001653-649 (649K)	24001652-246 (24.6K)	24001652-530 (53.0K)
−50 to +300°F	J	24001651-787 (7.87K)	24001653-649 (649K)	24001652-348 (34.8K)	24001652-453 (45.3K)
0-300°F	J	24001651-787 (7.87K)	24001653-681 (681K)	24001652-298 (29.8K)	24001652-523 (52.3K)
0-400°F	J	24001651-787 (7.87K)	24001653-576 (576K)	24001652-305 (30.5K)	24001652-388 (38.8K)
0-500°F	J	24001651-787 (7.87K)	24001653-511 (511K)	24001652-316 (31.6K)	24001652-309 (30.9K)
0-600°F	J	24001651-787 (7.87K)	24001653-453 (453K)	24001652-328 (32.8K)	24001652-255 (25.5K)
0-800°F	J	24001651-787 (7.87K)	24001653-374 (374K)	24001652-357 (35.7K)	24001652-191 (19.1K)
0-1000°F	J	24001651-787 (7.87K)	24001653-365 (365K)	24001652-388 (38.8K)	24001652-152 (15.2K)
0-1200°F	J	24001651-787 (7.87K)	24001653-301 (301K)	24001652-427 (42.7K)	24001652-124 (12.4K)
0-1600°F	J	24001651-787 (7.87K)	24001653-215 (215K)	24001652-556 (55.6K)	24001651-898 (8.98K)
50 to 650°F	J	24001651-787 (7.87K)	24001653-442 (442K)	24001652-287 (28.7K)	24001652-252 (25.2K)
50 to 1400°F	J	24001651-787 (7.87K)	24001653-255 (255K)	24001652-388 (38.8K)	24001652-109 (10.9K)
95 to 455°F	J	24001651-787 (7.87K)	24001653-576 (576K)	24001652-240 (24.0K)	24001652-422 (42.2K)
−45 to +150°C	J	24001651-787 (7.87K)	24001653-649 (649K)	24001652-348 (34.8K)	24001652-453 (45.3K)
−18 to +425°C	J	24001651-787 (7.87K)	24001653-374 (374K)	24001652-357 (35.7K)	24001652-191 (19.1K)
0-150°C	J	24001651-787 (7.87K)	24001653-698 (698K)	24001652-271 (27.1K)	24001652-576 (57.6K)
0-250°C	J	24001651-787 (7.87K)	24001653-536 (536K)	24001652-287 (28.7K)	24001652-340 (34.0K)
0-300°C	J	24001651-787 (7.87K)	24001653-475 (475K)	24001652-294 (29.4K)	24001652-284 (28.4K)
0-400°C	J	24001651-787 (7.87K)	24001653-392 (392K)	24001652-312 (31.2K)	24001652-210 (21.0K)
10 to 340°C	J	24001651-787 (7.87K)	24001653-442 (442K)	24001652-287 (28.7K)	24001652-255 (25.5K)
10 to 760°C	J	24001651-787 (7.87K)	24001653-255 (255K)	24001652-388 (38.8K)	24001652-109 (10.9K)
35 to 235°C	J	24001651-787 (7.87K)	24001653-576 (576K)	24001652-240 (24.0K)	24001652-422 (42.2K)
0-400°F	K	24001652-102 (10.2K)	24001653-732 (732K)	24001652-392 (39.2K)	24001652-511 (51.1K)
0-1000°F	K	24001652-102 (10.2K)	24001653-402 (402K)	24001652-493 (49.3K)	24001652-200 (20.0K)
0-1200°F	K	24001652-102 (10.2K)	24001653-402 (402K)	24001652-536 (53.6K)	24001652-167 (16.7K)
0-1600°F	K	24001652-102 (10.2K)	24001653-301 (301K)	24001652-657 (65.7K)	24001652-124 (12.4K)
0-2000°F	K	24001652-102 (10.2K)	24001653-243 (243K)	24001652-845 (84.5K)	24001652-101 (10.1K)
0-2400°F	K	24001652-102 (10.2K)	24001653-205 (205K)	24001653-113 (113K)	24001651-856 (8.56K)
+1365 to +1740°F	K	24001652-102 (10.2K)	24001653-464 (464K)	24001651-768 (7.68K)	24001652-549 (54.9K)
−18 to +1320°C	K	24001652-102 (10.2K)	24001653-205 (205K)	24001653-113 (113K)	24001651-856 (8.56K)
0-400°C	K	24001652-102 (10.2K)	24001653-499 (499K)	24001652-397 (39.7K)	24001652-280 (28.0K)
0-600°C	K	24001652-102 (10.2K)	24001653-374 (374K)	24001652-453 (45.3K)	24001652-184 (18.4K)
0-800°C	K	24001652-102 (10.2K)	24001653-294 (294K)	24001652-530 (53.0K)	24001652-138 (13.8K)
0-1000°C	K	24001652-102 (10.2K)	24001653-255 (255K)	24001652-634 (63.4K)	24001652-111 (11.1K)
0-1200°C	K	24001652-102 (10.2K)	24001653-215 (215K)	24001652-777 (77.7K)	24001651-909 (9.09K)
0-2500°F	R	24001652-706 (70.6K)	24001653-619 (619K)	24001654-120 (1.20M)	24001652-294 (29.4K)
30 to 2900°F	R	24001652-706 (70.6K)	24001653-590 (590K)	24001653-723 (723K)	24001652-246 (24.6K)
0-1600°C	R	24001652-706 (70.6K)	24001653-590 (590K)	24001653-723 (723K)	24001652-246 (24.6K)
0-1600°C	S	24001652-706 (70.6K)	24001653-576 (576K)	24001654-115 (1.15M)	24001652-274 (27.4K)
−250 to +150°F	T	24001652-102 (10.2K)	24001653-887 (887K)	24001652-768 (76.8K)	24001652-619 (61.9K)
−130 to +410°F	T	24001652-102 (10.2K)	24001653-619 (619K)	24001652-604 (60.4K)	24001652-357 (35.7K)
−100 to +100°C	T	24001652-102 (10.2K)	24001653-825 (825K)	24001652-569 (56.9K)	24001652-604 (60.4K)

TABLE 1 – Range Change Components (Continued)

Range	Sensor Type	R1	R2	R3	R4
−90 to +210°C	T	24001652-102 (10.2K)	24001653-619 (619K)	24001652-604 (60.4K)	24001652-357 (35.7K)
+75 to −200°C*	T	24001652-102 (10.2K)	24001653-835 (835K)	24001653-102 (102K)	24001652-530 (53.0K)
0-100°F	RTD (Ni-A)	—	24001653-140 (140K)	24001651-530 (5.30K)	24001652-142 (14.2K)
−200 to +100°F	RTD (Pt 100)	—	24001653-332 (332K)	24001652-604 (60.4K)	24001652-280 (28.0K)
−125 to +375°F	RTD (Pt 100)	—	24001653-205 (205K)	24001652-459 (45.9K)	24001652-172 (17.2K)
−35 to +75°F	RTD (Pt 100)	—	24001653-634 (634K)	24001652-294 (29.4K)	24001652-777 (77.7K)
−30 to +170°F	RTD (Pt 100)	—	24001653-499 (499K)	24001652-298 (29.8K)	24001652-427 (42.7K)
−25 to +125°F	RTD (Pt 100)	—	24001653-549 (549K)	24001652-287 (28.7K)	24001652-569 (56.9K)
0-100°F	RTD (Pt 100)	—	24001653-619 (619K)	24001652-267 (26.7K)	24001652-856 (85.6K)
0-200°F	RTD (Pt 100)	—	24001653-523 (523K)	24001652-274 (27.4K)	24001652-432 (43.2K)
0-350°F	RTD (Pt 100)	—	24001653-294 (294K)	24001652-287 (28.7K)	24001652-249 (24.9K)
0-400°F	RTD (Pt 100)	—	24001653-261 (261K)	24001652-291 (29.1K)	24001652-218 (21.8K)
0-600°F	RTD (Pt 100)	—	24001653-174 (174K)	24001652-305 (30.5K)	24001652-194 (14.9K)
20 to 120°F	RTD (Pt 100)	—	24001653-604 (604K)	24001652-255 (25.5K)	24001652-856 (85.6K)
50 to 250°F	RTD (Pt 100)	—	24001653-464 (464K)	24001652-243 (24.3K)	24001652-437 (43.7K)
250 to 450°F	RTD (Pt 100)	—	24001653-402 (402K)	24001652-169 (16.9K)	24001652-453 (45.3K)
−100 to +200°C	RTD (Pt 100)	—	24001653-191 (191K)	24001652-523 (52.3K)	24001652-160 (16.0K)
−95 to +49°C	RTD (Pt 100)	—	24001653-383 (383K)	24001652-437 (43.7K)	24001652-328 (32.8K)
−85 to +190°C	RTD (Pt 100)	—	24001653-205 (205K)	24001652-448 (44.8K)	24001652-174 (17.4K)
−75 to +260°C	RTD (Pt 100)	—	24001653-174 (174K)	24001652-437 (43.7K)	24001652-145 (14.5K)
−50 to +25°C	RTD (Pt 100)	—	24001653-604 (604K)	24001652-316 (31.6K)	24001652-634 (63.4K)
−35 to +75°C	RTD (Pt 100)	—	24001653-511 (511K)	24001652-298 (29.8K)	24001652-432 (43.2K)
−30 to +70°C	RTD (Pt 100)	—	24001653-523 (523K)	24001652-291 (29.1K)	24001652-475 (47.5K)
−25 to +125°C	RTD (Pt 100)	—	24001653-365 (365K)	24001652-291 (29.1K)	24001652-320 (32.0K)
−18 to +94°C	RTD (Pt 100)	—	24001653-523 (523K)	24001652-274 (27.4K)	24001652-432 (43.2K)
−5 to +50°C	RTD (Pt 100)	—	24001653-604 (604K)	24001652-252 (25.2K)	24001652-866 (86.6K)
0 to −100°C*	RTD (Pt 100)	—	24001653-549 (549K)	24001652-232 (23.2K)	24001652-464 (46.4K)
0-100°C	RTD (Pt 100)	—	24001653-499 (499K)	24001652-252 (25.2K)	24001652-481 (48.1K)
0-200°C	RTD (Pt 100)	—	24001653-287 (287K)	24001652-264 (26.4K)	24001652-246 (24.6K)
0-400°C	RTD (Pt 100)	—	24001653-150 (150K)	24001652-291 (29.1K)	24001652-126 (12.6K)
+49 to −95°C*	RTD (Pt 100)	—	24001653-383 (383K)	24001652-191 (19.1K)	24001652-328 (32.8K)
+50 to −85°C*	RTD (Pt 100)	—	24001653-412 (412K)	24001652-191 (19.1K)	24001652-348 (34.8K)

*Reverse range requires wiring change to SB connector. Refer to "Board Wiring Changes" paragraph.

TABLE 1 - Range Change Components (Continued)

Range	Sensor Type	R1	R2	R3	R4
70 to 140°C	RTD (Pt 100)	——	24001653-499 (499K)	24001652-193 (19.3K)	24001652-698 (69.8K)
+120 to −140°F*	RTD (Pt 100)	——	2400653-383 (383K)	24001652-191 (19.1K)	24001652-324 (32.4K)
−100 to +100°C	DIN RTD (Pt 100)	——	24001653-287 (287K)	24001652-470 (47.0K)	24001652-240 (24.0K)
−40 to +60°C	DIN RTD (Pt 100)	——	24001653-536 (536K)	24001652-301 (30.1K)	24001652-481 (48.1K)
−10 to +60°C	DIN RTD (Pt 100)	——	24001653-576 (576K)	24001652-258 (25.8K)	24001652-698 (69.8K)
0-100°C	DIN RTD (Pt 100)	——	24001653-499 (499K)	24001652-252 (25.2K)	24001652-487 (48.7K)
0-200°C	DIN RTD (Pt 100)	——	24001653-294 (294K)	24001652-264 (26.4K)	24001652-294 (24.9K)
0-250°C	DIN RTD (Pt 100)	——	24001653-237 (237K)	24001652-271 (27.1K)	24001652-200 (20.0K)
0-400°C	DIN RTD (Pt 100)	——	24001653-154 (154K)	24001652-287 (28.7K)	24001652-129 (12.9K)
0-50°F	RTD (Pt 200)	——	24001653-412 (412K)	24001652-132 (13.2K)	24001652-856 (85.6K)
0-200°F	RTD (Pt 200)	——	24001653-255 (255K)	24001652-137 (13.7K)	24001652-215 (21.5K)
−100 to +200°C	RTD (Pt 200)	——	24001652-953 (95.3K)	24001652-258 (25.8K)	24001651-796 (7.96K)
−76 to +100°C	RTD (Pt 200)	——	24001653-162 (162K)	24001652-196 (19.6K)	24001652-135 (13.5K)
−75 to +180°C	RTD (Pt 200)	——	24001653-110 (110K)	24001652-205 (20.5K)	24001651-942 (9.42K)
0-50°C	RTD (Pt 200)	——	24001653-340 (340K)	24001652-123 (12.3K)	24001652-481 (48.1K)
50 to 150°F	RTD (Pt 500)	——	24001653-274 (274K)	24001651-953 (9.53K)	24001652-348 (34.8K)
0-50°F	Δ RTD (Pt 200)	——	24001653-332 (332K)	24001653-203 (203K)	24001652-149 (14.9K)
63 to 0°F	Δ RTD (Pt 200)	——	24001653-140 (140K)	24001652-154 (15.4K)	24001652-118 (11.8K)
35 to 0°C	Δ RTD (Pt 200)	——	24001653-140 (140K)	24001652-154 (15.4K)	24001652-118 (11.8K)
20 to 0°F	Δ RTD (Pt 500)	——	24001653-365 (365K)	24001652-213 (21.3K)	24001652-156 (15.6K)
2 to 98%	RH (Q457B)	——	24001653-113 (113K)	24001652-732 (73.2K)	24001651-909 (9.09K)
0-100[a]	1000 Ω slidewire	24001651-732 (7.32K)	24001653-243 (243K)	24001652-221 (22.1K)	24001652-102 (10.2K)
0-10[a]	mV dc	——	24001653-866 (866K)	24001653-517 (517K)	24001652-464 (46.4K)
0-25	mV dc	——	24001653-422 (422K)	24001653-205 (205K)	24001652-184 (18.4K)
0-30	mV dc	——	24001653-365 (365K)	24001653-172 (172K)	24001652-154 (15.4K)
0-100	mV dc	——	24001654-124 (1.24M)	24001654-104 (1.04M)	24001652-931 (93.1K)
0-200[a]	mV dc	——	24001653-866 (866K)	24001653-517 (517K)	24001652-464 (46.4K)
0-500[a]	mV dc	——	24001653-866 (866K)	24001653-517 (517K)	24001652-459 (45.9K)
15-25	mV dc	——	24001653-590 (590K)	24001652-218 (21.8K)	24001652-464 (46.4K)
25-0*	mV dc	——	24001653-422 (422K)	24001653-205 (205K)	24001652-184 (18.4K)
50-0*	mV dc	——	24001653-221 (221K)	24001653-102 (102K)	24001651-920 (9.20K)
0-10[a]	mA dc	——	24001653-442 (442K)	24001653-208 (208K)	24001652-184 (18.4K)
4-20[a]	mA dc	——	24001653-274 (274K)	24001652-556 (55.6K)	24001652-115 (11.5K)
4-22.29[a]	mA dc	——	24001653-221 (221K)	24001652-642 (64.2K)	24001652-101 (10.1K)
0-1[a]	Vdc	——	24001654-124 (1.24M)	24001654-104 (1.04M)	24001652-931 (93.1K)
0-5[a]	Vdc	——	24001653-442 (442K)	24001653-208 (208K)	24001652-187 (18.7K)
0-10	Vdc	——	24001653-221 (221K)	24001653-104 (104K)	24001651-931 (9.31K)
1-5[a]	Vdc	——	24001653-464 (464K)	24001653-113 (113K)	24001652-232 (23.2K)
0-14[a]	pH[c]	——	24001653-274 (274K)	24001652-556 (55.6K)	24001652-115 (11.5K)
0-120[a]	c	——	24001653-274 (274K)	24001652-556 (55.6K)	24001652-115 (11.5K)
0-350[a]	c	——	24001653-274 (274K)	24001652-556 (55.6K)	24001652-115 (11.5K)
0-100[b]	c	——	24001653-274 (274K)	24001652-556 (55.6K)	24001652-115 (11.5K)
0-100[b]	d	——	24001653-464 (464K)	24001653-113 (113K)	24001652-232 (23.2K)

[a](linear or evenly-spaced chart divisions) [c](4 to 20 mA dc)
[b](square root chart divisions) [d](1 to 5 Vdc)
*Reverse range requires wiring change to SB connector.

TABLE 2 - Sensor/Actuation Change Signal Conditioning[a]

Sensor Type	S_A Connector: Component(s)	S_A Connector: Plug onto Posts	Fixed Jumpers & Resistors - board wiring must include only:
Thermocouple E J K T	24120092-001	2 to 5[b]	J31 R10 (10KΩ, part #802139BAACA) R11 (2.7KΩ, part #192009CHCA) Compensator (part #24110226-001)
R, S	24120092-001	2 to 5[b]	J30, R10, R11, Compensator
RTD Pt 100Ω Pt 200Ω Pt 500Ω DIN Pt 100Ω Ni-A	24120092-003 24120092-004	2 to 5 1 to 3	J38, R10,[c] R11
ΔRTD Pt 200Ω[d] Pt 500Ω	24110238-001	1 through 6	J30, R10,[c] (clip out R11)
RH Q457B	24110239-001	1 through 7	J30, J33, R10,[c] (clip out R11)
Slidewire Transducer, 1000Ω	24120092-001	2 to 5	J30, R11, (clip out R10)
	24120092-004	1 to 6	
Vdc	24120103-004	2 to 4 (1MΩ)	J30, R10,[c] (clip out R11)
0 to XXX		4 to 6 (4.99KΩ)	
1 to XXX			J31, R10,[c] (clip out R11)
mV dc 0 to 10	24120092-001	2 to 5[b]	J30, R10,[c] R11
0 to 200	24120103-006	2 to 4[b] (143KΩ)	J30, R10,[c] (clip out R11)
		4 to 6 (7.5KΩ)	
0 to 500	24120103-005	2 to 4[b] (365KΩ)	J30, R10[c], (clip out R11)
		4 to 6 (7.5KΩ)	
mA dc 4 to 20 4 to 22.29	24120092-002	2 to 6	J31, R10,[c] R11

[a]Refer as needed to "Board Wiring Changes" paragraph.
[b](Upscale sensor break protection) For downscale "burnout" use post 3 in place of post 5.
[c]R10 is not necessary to this actuation but may remain on the PCB without effect.
[d]0–50°F range uses J31, R10,[c] (clip out R11) for board wiring.

Board Wiring Changes

Jumpers and Resistors (Figure 1)

A circuit board may require changes or additions of jumpers or resistors to match the sensor conditioning requirements of Table 2. Unplug wiring connectors from the front of the board, remove wiring from terminals, and remove the 6 screws holding the board in the case. Use a low power soldering iron (30 watts maximum) and a solder suction tool or solder wick material to remove solder from required points. Be sure to remove any jumpers or resistors not required for desired actuation. Place required jumpers and/or resistors in position and carefully solder them. (Do not allow solder to "bridge over" to other components.) Replace the board in the case with the 6 screws; replace wiring to terminals as previously connected; plug wiring connectors onto the board as before. (Connection points are shown in the upper portion of Figure 1.)

SB Connector

Reverse ranges indicated in Table 1 require repositioning of leadwires in the connector plug. Interchange leadwires in positions 3 and 4 (red and green) and positions 6 and 8 (red and green). Leadwires are anchored in the plug by a small metal tab (Figure 2). To remove a wire from its position, use a small screwdriver (or the point of a sewing needle) to press the tab flush with the surrounding metal while pulling the wire out of the plug. Be careful not to break the tab. Check the tab before re-inserting a wire to ensure that the tab is not permanently flattened into the leadwire sheath. Use a thin knife blade (or the point of a sewing needle) if necessary to restore the tab to its proper shape and position. Re-insert a wire into the plug in the desired position so that the tab locks the leadwire sheath in place in the plug.

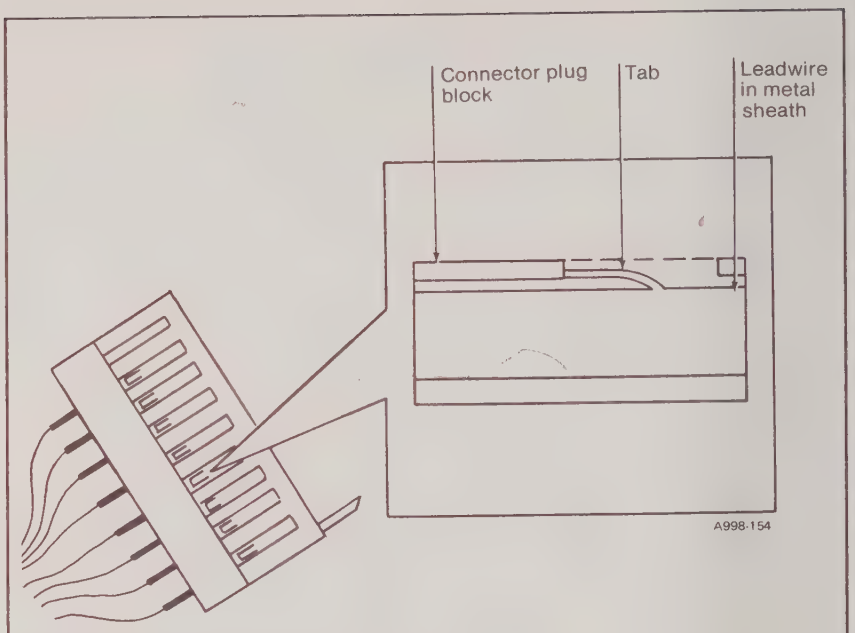


Figure 2 – Wire Anchoring/Removal in SB Connector

Calibration

There are 2 parts to the calibration procedures:

1. Adjust the zero and span for the specific controller board sensor actuation. NOTE: To minimize repeated readjustments, pre-adjust P2 and P3 to their approximate mid-positions before performing initial calibration adjustments. Consult Table 3 for required calibration tools and perform the steps in the specific following paragraph that applies to that sensor actuation type. (Disconnect sensor and process wiring from instrument and replace with appropriate simulations.)

TABLE 3 – Calibration Tools per Sensor Type

Sensor/Actuation Types								
Vdc	mV dc	mA dc	Thermocouple	RTD	Δ RTD	RH	1K Ω Slidewire	Tools
1	1	1	1	1	1	1	1	Small-bladed "jeweler's type" screwdriver
1	1	1	1	1	1	1	1	Hand-held electronic calculator[a]
X	X	X	X	X	X	X	X	Copper connecting wires for input source
1	1	1	1	1	1	1	1	Multi-range Multi Meter (volts, ohms, amps) capable of reading to 10 μV (DMM preferrable)
1	1	1	1	1	1	1	1	600 ohm load resistor[b]
1	1	1	1					Portable input voltage/current source (compatible with range of instrument)
			1					Glass bulb thermometer (to measure ambient temperature at instrument)
			1	1	1			Tables of Thermocouple Temperature millivolt equivalents and RTD Resistance vs. Temperature (Honeywell literature number 25-75-05-02[c] or other as available)
				1	2			Precision decade resistance box, 0 to 999.99 ohms (0.01Ω resolution)
						X		Precision resistors: 51.28KΩ and 222.2KΩ, or Precision decade resistance box 0 to 999.99KΩ (10Ω resolution)
							1	Precision potentiometer, 1KΩ slidewire

[a]Optional, but useful

[b]Connect across controller output terminals to simulate process connection.

[c](formerly called 892-1)

2. Perform the steps in the "Set Point Alignment Check" paragraph.

   NOTE: Adjust potentiometer P6 (of controllers so equipped) to the approximate mid-position before aligning set point mechanisms. P6 is a balancing potentiometer mounted on the controller board of Two-Position control models. On proportional control models P6 (A or B) is the Manual Reset potentiometer mounted at the right side of the case and wired back to the controller board.

Vdc, mV dc, mA dc

1. Determine the appropriate input signal levels for 0 percent and 100 percent of the desired instrument range. For example, on an instrument conditioned to accept 4 to 20 mA dc input for a 0 to 100 linear range: 4 mA is the 0% signal; 20 mA is the 100% signal.
2. Connect the portable input source to the sensor input terminals.
3. Adjust the input source to the 0% signal level.
4. Adjust "ZERO" potentiometer P2 to align the pen point with the zero point position on the paper chart of the desired range.
5. Adjust the input source to the 100% signal level.
6. Adjust "SPAN" potentiometer P3 to align pen point with the 100% point position on the paper chart.
7. Repeat steps 3 through 6 until further readjustment is not needed.

Thermocouple

1. Place the glass bulb thermometer in the instrument case near the sensor terminals to determine the ambient temperature. Find the millivolt equivalent of this temperature for the appropriate thermocouple in the table (e.g., Honeywell booklet 25-75-05-02 or equivalent). This millivoltage value is the "ambient temperature allowance".
2. Consult Table 4 to determine the correct compensator millivoltage for a given thermocouple type and ambient temperature. (An example is given at the bottom of the table.)
3. Measure the voltage across the compensator resistor (terminals 2 to 3) and adjust potentiometer P1 to establish the correct voltage across the compensator.
4. Determine the appropriate input signal levels for 0 percent ("Zero calibration point") and 100 percent ("Span calibration point") of the desired instrument range. For example:

   Assume that a Type J thermocouple (range 0 to 800°F) is being used with the controller and that the ambient temperature is determined as 80°F. In this case, the ambient temperature allowance equals +1.363 mV which is the millivolt equivalent for a type J thermocouple at 80°F; and desired zero and span calibration points are 0°F and 800°F, respectively. The calibration millivoltage for zero calibration point is determined as follows:

   0°F = −0.885 mV = zero calibration point

   80°F = +1.363 mV = ambient temperature allowance.

   Then, zero calibration point minus ambient temperature allowance equals:

   −0.885 − 1.363 = −2.248 mV

   Thus −2.248 mV is the value to be set on the input source to simulate the 0% signal.

   Likewise, span calibration point millivoltage is:

   800°F = 23.317 mV = span calibration point

   80°F = 1.363 mV = ambient temperature allowance

   Then, 23.317 − 1.363 = 21.954 mV. Thus, 21.954 mV is the value to set on the input source to simulate the 100% signal.
5. Connect the portable input source to the sensor input terminals.
6. Adjust the input source to the 0% signal level.
7. Adjust "ZERO" potentiometer P2 to align the pen point with the zero point position on the paper chart of the desired range.
8. Adjust the input source to the 100% signal level.
9. Adjust "SPAN" potentiometer P3 to align the pen point with the 100% point position on the paper chart.
10. Repeat steps 6 through 9 until further readjustment is not needed.

RTD

1. Determine the appropriate input resistances for 0 percent and 100 percent of the desired instrument range from the equivalence tables* (e.g., in the back of the Honeywell booklet 25-75-05-02). For example: assume an instrument which measures a range of 50°F to 250°F with a 100Ω platinum RTD. The resistance at 50°F (0%) is 103.95 ohms. The resistance at 250°F (100%) is 147.11 ohms.

   NOTE: Leadwire resistance must also be accounted for during calibration (except when 3 wire RTD connections are used). If the total resistance of the leadwires from the instrument to the RTD and back to the instrument terminals equals 0.5 ohms, then the decade box must be set 0.5 ohms higher than the table values (i.e., 103.95 plus 0.5 equals 104.45 ohms for 0% or 50%F, 147.11 plus 0.5 equals 147.61 ohms for 100% or 250°F).
2. Connect the decade resistance box to input terminals 1 and 3 of the controller board. (Refer to wiring label on chart plate back for 3 wire sensor connection.)
3. Adjust the input resistance to the 0% value.
4. Adjust "ZERO" potentiometer P2 to align the pen point with the zero point position on the paper chart of the desired range.
5. Adjust the input resistance to the 100% value.
6. Adjust "SPAN" potentiometer P3 to align the pen point with the 100% point position on the paper chart.
7. Repeat steps 3 through 6 until further readjustment is not needed.

*Refer to the "Interpolation of RTD tables" inset as needed.

TABLE 4 – Compensator Values Table

Thermocouple Type	Compensator Voltage at 80°F (26.7°C)	Correction Factor
J	13.54 ±0.14 mV dc	+0.029 mV/°F (0.0522 mV/°C)
K	10.58 ±0.11 mV dc	+0.023 mV/°F (0.0414 mV/°C)
R	1.55 ±0.10 mV dc	+0.003 mV/°F (0.0054 mV/°C)
S	1.54 ±0.10 mV dc	+0.003 mV/°F (0.0054 mV/°C)
T	10.66 ±0.11 mV dc	+0.023 mV/°F (0.0414 mV/°C)
E	15.96 ±0.16 mV dc	+0.034 mV/°F (0.0612 mV/°C)

Example: Type J Thermocouple, temperature measured at compensator is 86°F (30°C).

V_{COMP} (°F) = 13.54 + 0.029 (86−80) = 13.71 ±0.14 mV dc
V_{COMP} (°C) = 13.54 + 0.0522 (30−26.7) = 13.71 ±0.14 mV dc

Remember: $x°F = \frac{5}{9}(x-32)°C$, and $y°C = (1.8y + 32)°F$

ΔRTD (Wet/Dry Bulb)

1. Determine the appropriate input resistances for the desired instrument range from the equivalence tables* (e.g., in the back of the Honeywell 25-75-05-02 booklet) and construct a calibration table which matches the given application, similar to Table 5.
2. Connect the decade resistance boxes to the input terminals (Figure 3).
3. Adjust the reference (dry bulb) decade box to the equivalent resistance of the reference temperature.
4. Adjust the measuring (wet bulb) decade box to the equivalent resistance of 0% full scale.
5. Adjust "ZERO" potentiometer P2 to align the pen point with the minimum scale position on the paper chart of the desired range. (For a 63°F to 0°F range, this is the 63°F position, toward the chart hub.)
6. Adjust the measuring (wet bulb) decade box to the equivalent resistance of 100% full scale (usually the same resistance value as the reference decade box).
7. Adjust "SPAN" potentiometer P3 to align the pen point with the maximum scale position on the paper chart of the desired range. (For a 63°F to 0°F range, this is the 0°F position, toward the outer edge of the chart.)
8. Repeat steps 3 through 7 until further readjustment is not needed.

*Refer to the "Interpolation of RTD tables" inset as needed.

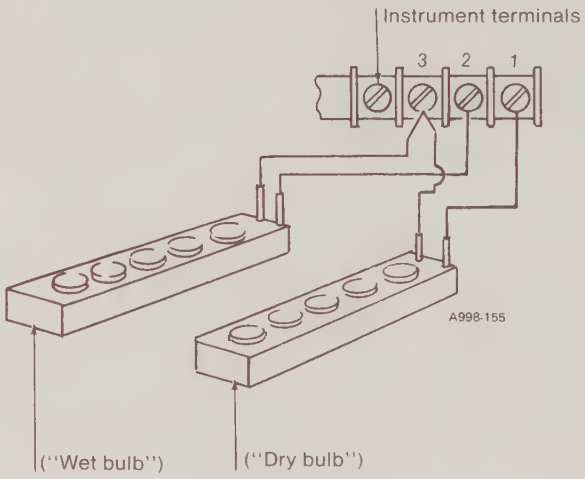


Figure 3 – ΔRTD Calibration Connections

RH (Q457B Sensor)

This calibration procedure is based on calculations for an approximate ambient temperature of 80°F (26.67°C). Zero and span adjustments are performed for 20% and 80% RH respectively for optimum accuracy across the instrument range.

1. Connect the high resistance decade box (or 222.2KΩ resistor) to input terminals 1 and 2 of the controller board and adjust the resistance to the 20% RH value (222.2KΩ).
2. Adjust "ZERO" potentiometer P2 to align the pen point with the 20% point position on the 0 to 100 paper chart.
3. Adjust the decade box to the 80% RH value (or replace the 222.2KΩ resistor with the 51.28KΩ resistor).
4. Adjust "SPAN" potentiometer P3 to align pen point with the 80% point position on the 0 to 100 paper chart.
5. Repeat steps 1 through 4 (as needed) until further readjustment is not needed.

TABLE 5 – Sample Values[a] for Δ RTD Calibration

Reference ("dry bulb") Temperature	Equivalent Resistance (RTD + Leadwire)	Measured ("wet bulb") Temperature	Equivalent Resistance (RTD + Leadwire)	Δ T[b] (in °F)	% Full Scale
120°F	238.44 + 0.50 = 238.94	120°F	238.44 + 0.50 = 238.94	0	100
120°F	238.44 + 0.50 = 238.94	113.7°F	235.70 + 0.50 = 236.20	6.3	90
120°F	238.44 + 0.50 = 238.94	107.4°F	232.98 + 0.50 = 233.48	12.6	80
120°F	238.44 + 0.50 = 238.94	88.5°F	224.74 + 0.50 = 225.24	31.5	50
120°F	238.44 + 0.50 = 238.94	69.6°F	216.51 + 0.50 = 217.01	50.4	20
120°F	238.44 + 0.50 = 238.94	63.3°F	213.73 + 0.50 = 214.23	56.7	10
120°F	238.44 + 0.50 = 238.94	57°F	210.98 + 0.50 = 211.48	63	0

[a]Based on a differential temperature range of 63°F to 0°F (0% to 100% of the chart scale/instrument span) measured by 200Ω platinum RTD's. The nominal reference (dry bulb) temperature is considered at 120°F with measured (wet bulb) temperatures as listed.
NOTE: Leadwire resistance must also be accounted for during calibration. The total leadwire resistances from the instrument terminals out to each RTD and back to the instrument are assumed to be 0.5 ohms. Substitute the measured leadwire resistances of a given application for the assumed 0.5 ohms if possible.
[b]If the instrument range is desired to read zero differential temperature at 0% fullscale and maximum ΔT at 100% fullscale (e.g., 0°F to 50°F), consider the "wet bulb" decade box of Figure 3 as the reference and the "dry bulb" decade box as the measured temperature.

1KΩ Slidewire Transducer

1. Connect the 1KΩ slidewire potentiometer across input terminals 2 and 3 with the slidewire wiper to terminal 1.
2. Adjust the potentiometer to the 0% input level (i.e., 50 ohms resistance* between terminals 1 and 3).
3. Adjust "ZERO" potentiometer P2 to align the pen point with the 0% point position on the paper chart of the desired range.
4. Adjust the potentiometer to the 100% input level (i.e., 950* ohms resistance between terminals 1 and 3).
5. Adjust "SPAN" potentiometer P3 to align the pen point with the 100% point position on the paper chart.
6. Repeat steps 2 through 5 until further readjustments is not needed.

Set Point Alignment Check

1. Remove pen cartridge(s) and chart. (Connect input source if not already connected.)
2. Adjust the input source to align the V-notch at the end of the pen arm with the mid-scale position mark on the chart plate.
3. Measure the voltage between the servo wiper and the set point wiper (TP1 or SB5 to SB7) and adjust the set point index or move the cam follower arm toward the pen arm position until the voltage between the wipers is 0 ±25 mV.
4. If the set point index or cam follower arm is not aligned exactly with the pen arm, readjust as follows:
   a. Set Point Index: Loosen two screws at pointer base, align the pointer with the pen arm and chart plate mark, and retighten the screws.
   b. Cam Follower Arm: With one hand hold in position the spring-loaded support base to which the arm is attached. (This positioning of the support base must maintain the voltage between the wipers at 0 ±25 mV.) Simultaneously loosen the three screws which attach the arm to the support base, align the arm with the pen arm and chart plate mark, and retighten the screws.
5. Place a fresh chart on the drive hub and replace the pen cartridge(s) onto the pen arm(s).

*NOTE: This transducer uses only 900Ω in the active region, with a 50Ω buffer at either end.

Interpolation of RTD Tables

The desired temperature and its resistance equivalent may fall between values which are listed in the equivalence tables. Find the desired values by calculating proportionally between the closest higher and lower values as follows:

1. Identify:
   A = the desired temperature value
   B = the temperature value, listed in the table, which is closest to and lower than A
   C = the temperature value, listed in the table, which is closest to and higher than A
   D = the resistance value listed for C, multiplied by factor F
   E = the resistance value listed for B, multiplied by factor F
   F = 1 for a 100Ω platinum RTD
   2 for a 200Ω platinum RTD
   5 for a 500Ω platinum RTD

2. The desired value $= \left[\left(\frac{A-B}{C-B}\right) \times (D-E)\right] + (E)$

For example: Find the desired resistance value for a 200Ω platinum RTD at 113.7°F

A = 113.7°F
B = 110°F
C = 115°F
D = (118.14) (2) = 236.28Ω
E = (117.05) (2) = 234.10Ω
F = 2 (200Ω RTD)

Then,

the desired resistance $= \left[\left(\frac{113.7-110}{115-110}\right) \times (236.28-234.10)\right] + (234.10)$

$= \left[\left(\frac{3.7}{5}\right) \times (2.18)\right] + (234.10) = [(0.74) \times (2.18)] + (234.10)$

$= [1.6132] + (234.10) = 235.7132 \approx 235.71\Omega$

(Round off to two decimal places at the end of the calculation).

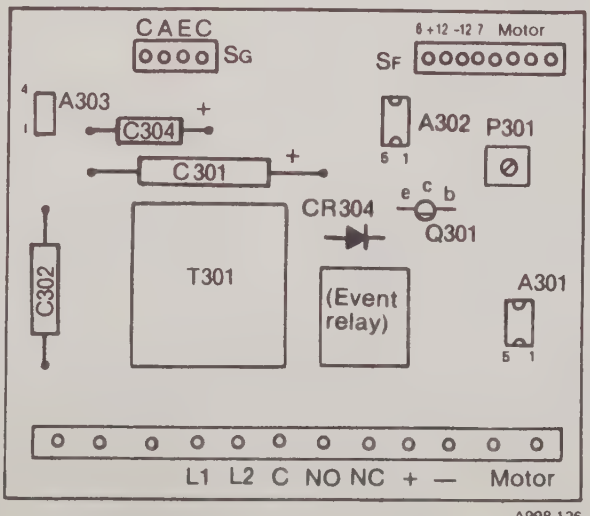


Figure 4 – Optical Event Switching and Programming Output Board

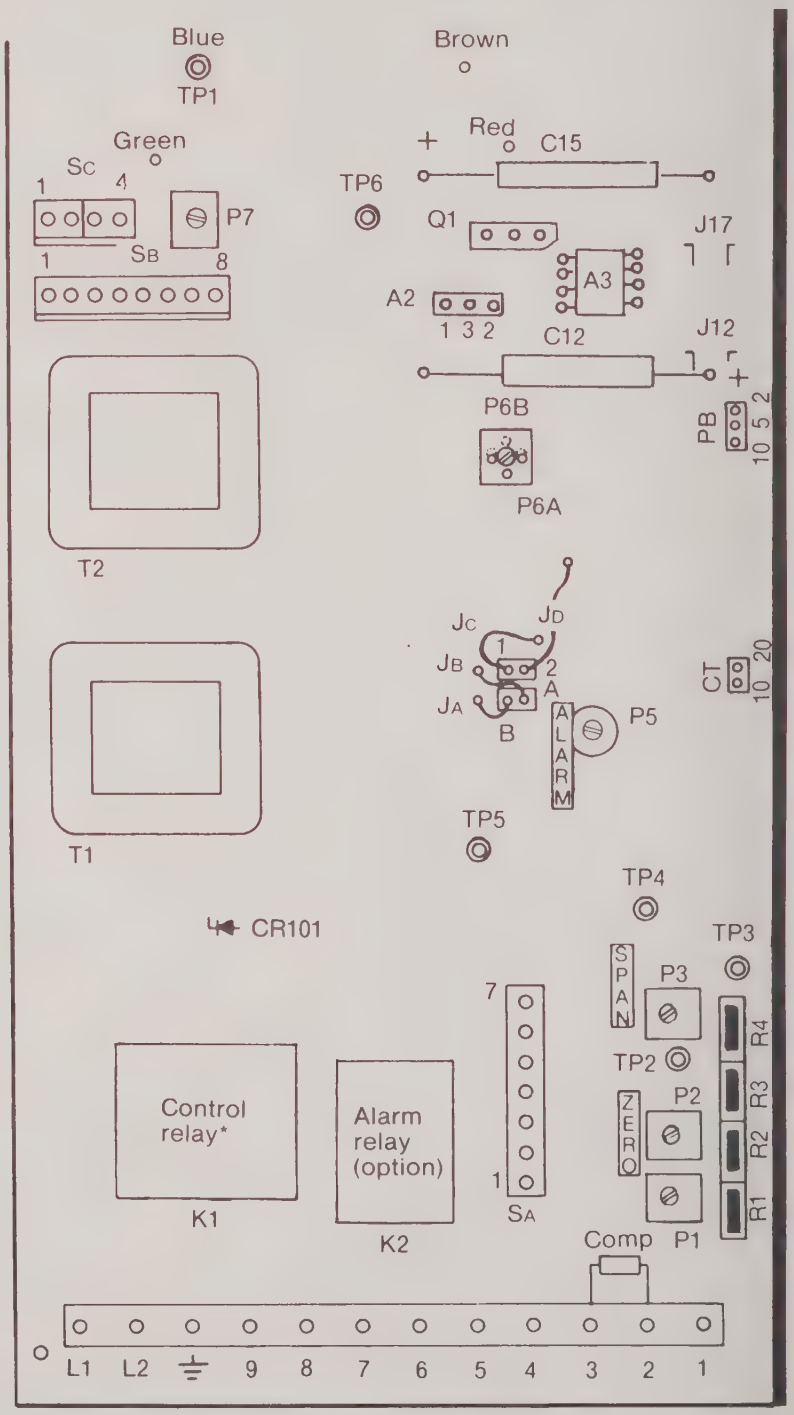
Troubleshooting

The following list of symptoms refers to an appropriate flowchart which presents troubleshooting steps.

Problem	Flow-chart No.	Page
Controller will not operate	1	13
Recorder operation normal, but pen trace seems incorrect	2	15
Chart rotates at wrong speed or not at all, while pen indication is correct	3	18
Pen will indicate only in outer area of chart (high end of range) even if input signal is low	4	19
Pen indication remains at outer edge (high side) of chart	4	19
Pen will not move regardless of input	5	20
Optical event switch will not operate*	6	23
Programming output incorrect or not functioning*	7	26
High limit control will not operate*	8	27
Process Variable output incorrect or not functioning (3-mode controllers only)	9	28

*(for models so equipped)

Refer to Figures 4, 5, 6, and 7 as needed to locate test points, components, etc.



*(Used only on 2-position and time proportioning controllers)
NOTE: Current Proportioning Mode jumpers (J_C & J_D) are shown in Inverse Mode position. Alarm mode jumpers (J_A & J_B) are shown in High Alarm position.

A998-66-1

Figure 5 – Main Printed Circuit Board (major components shown)

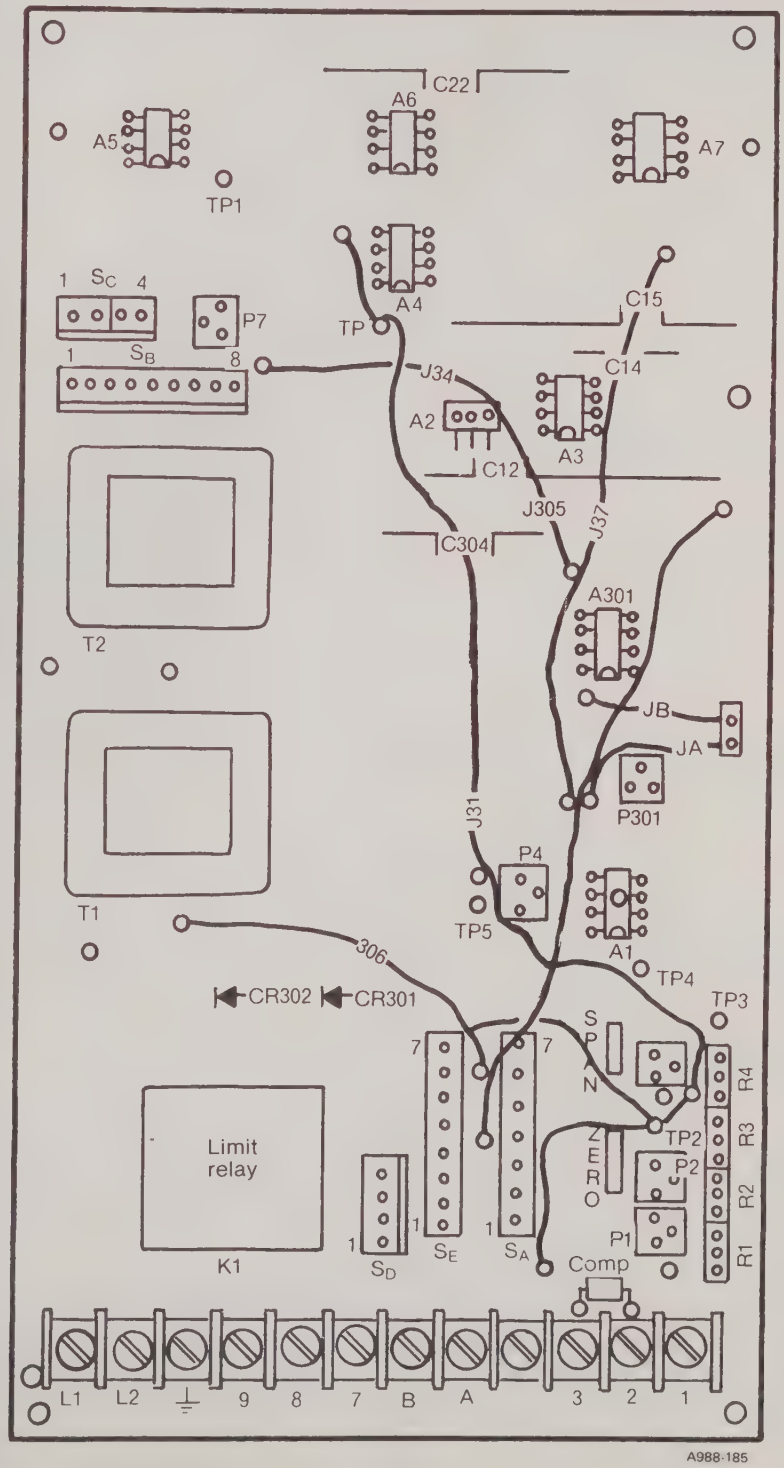


Figure 6 – Main Printed Circuit Board for Units with High (Low) Limit control.
[JA, JB shown in High Limit position]

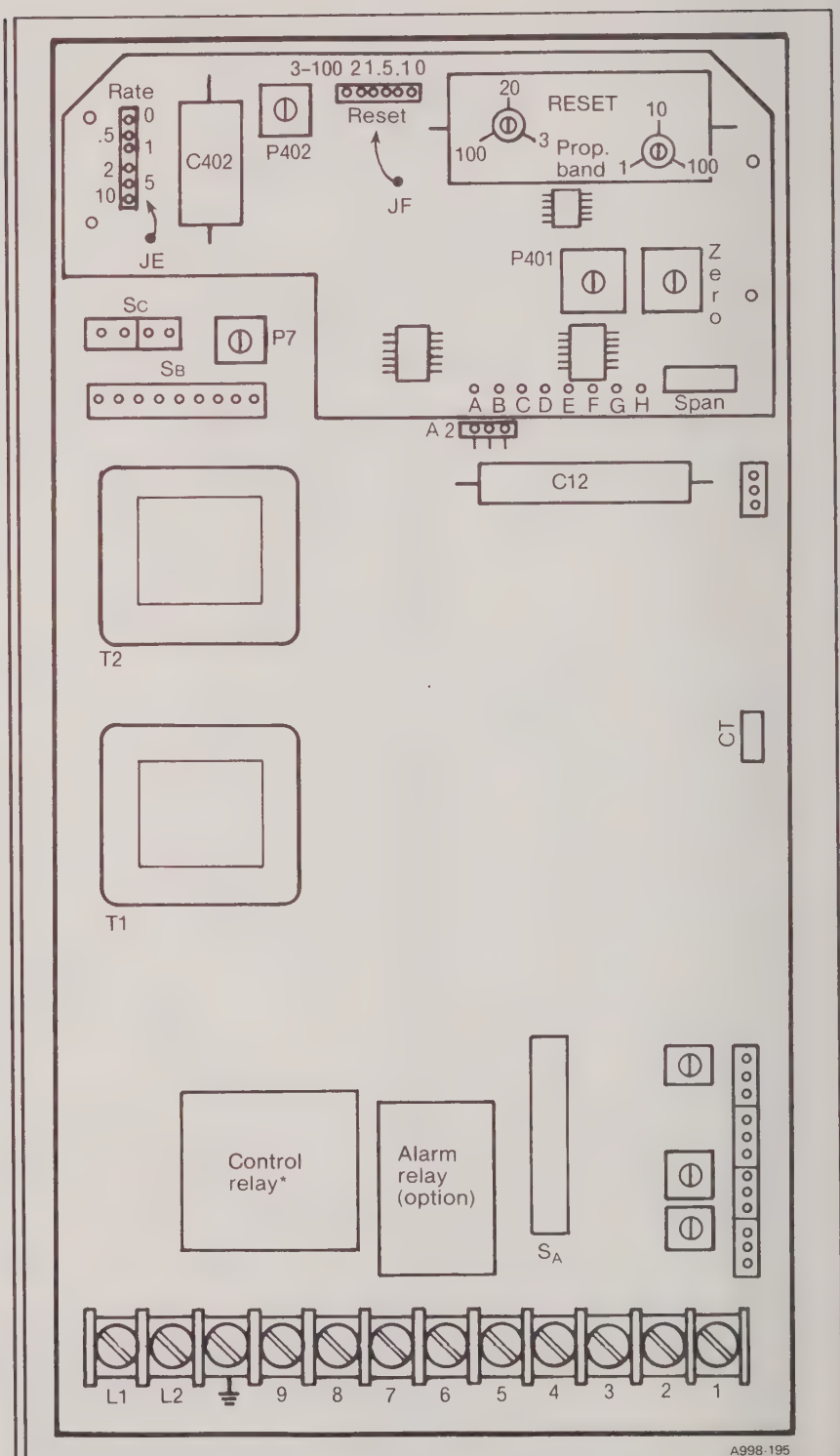
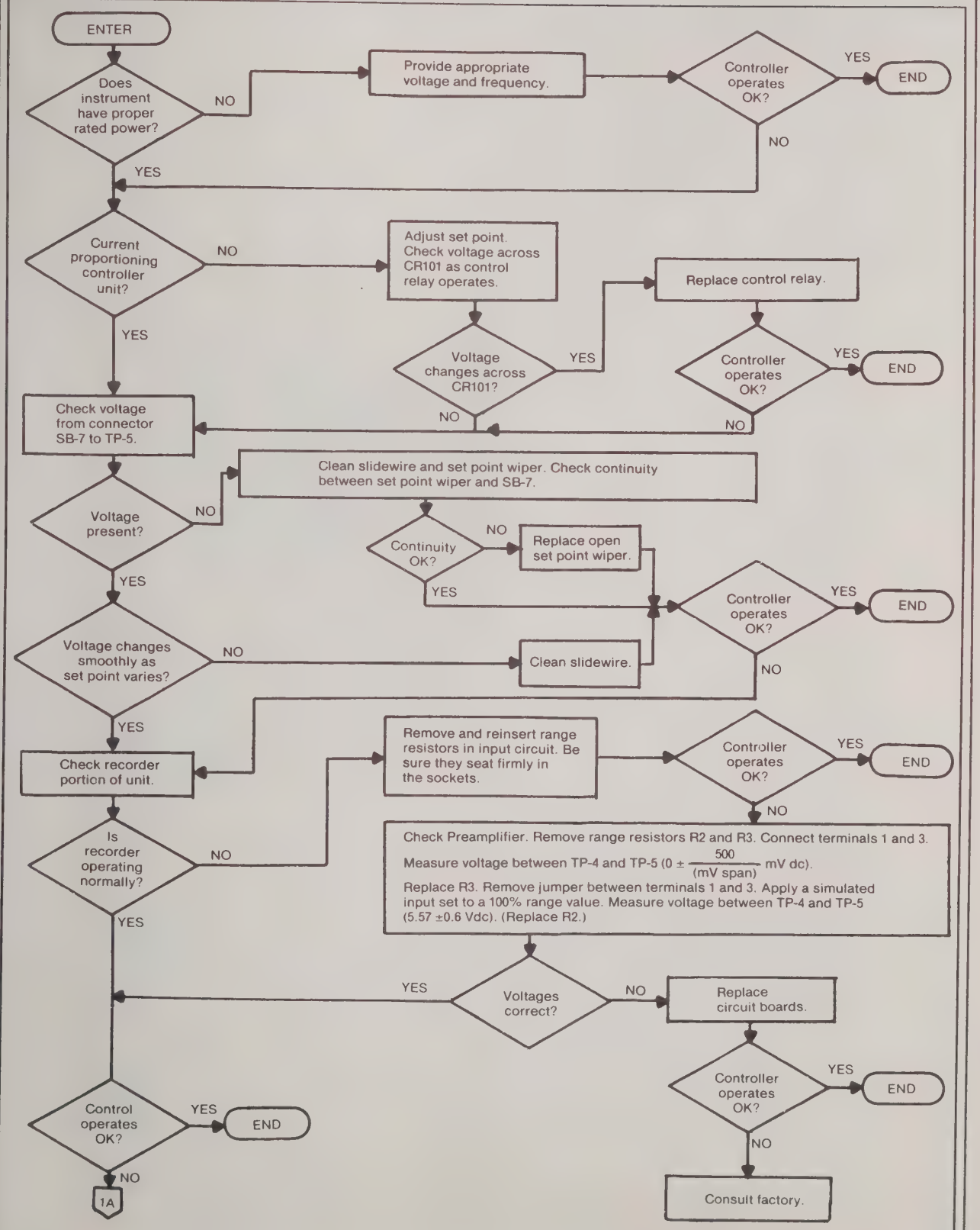
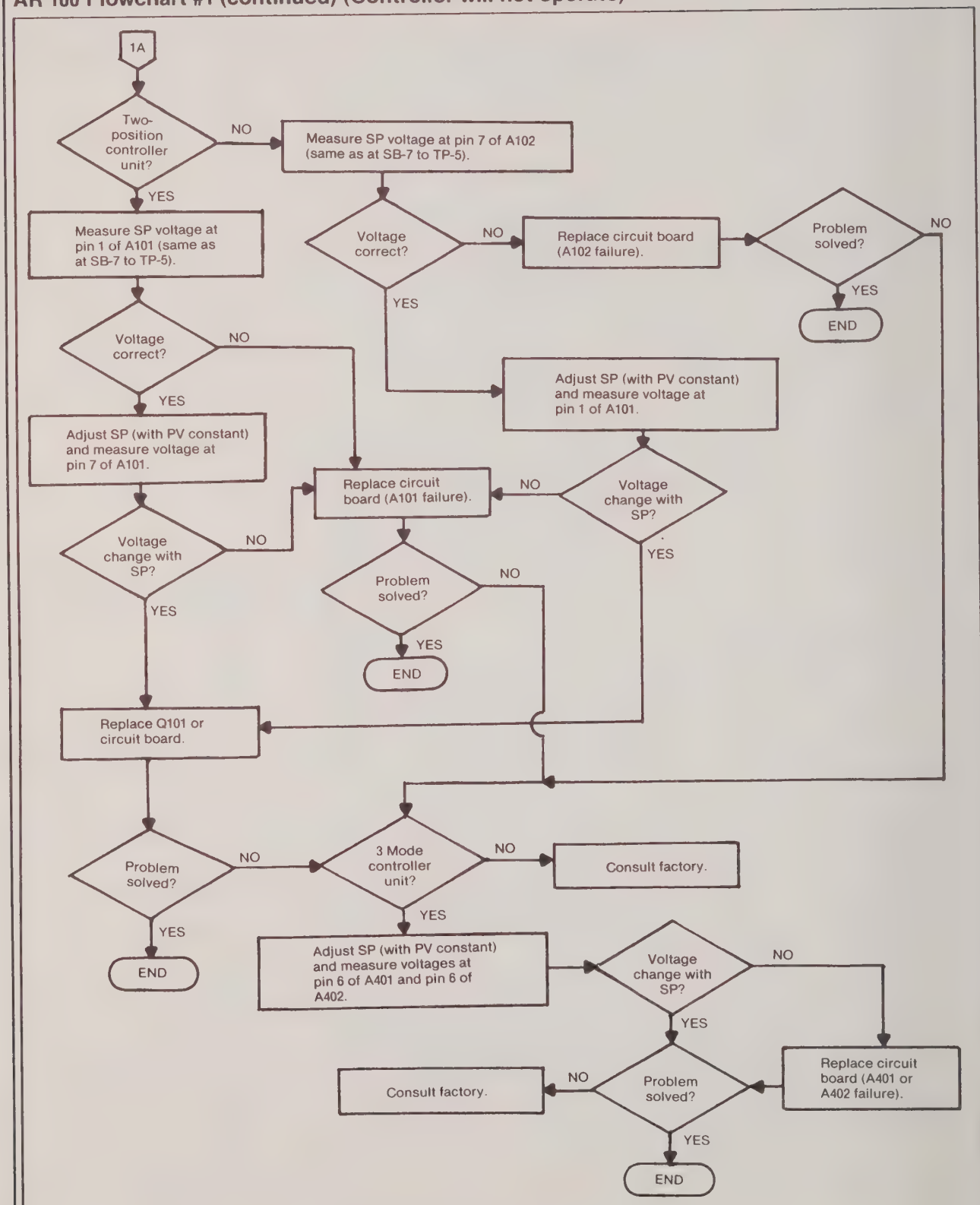


Figure 7 – Three-Mode Controller Printed Circuit Board

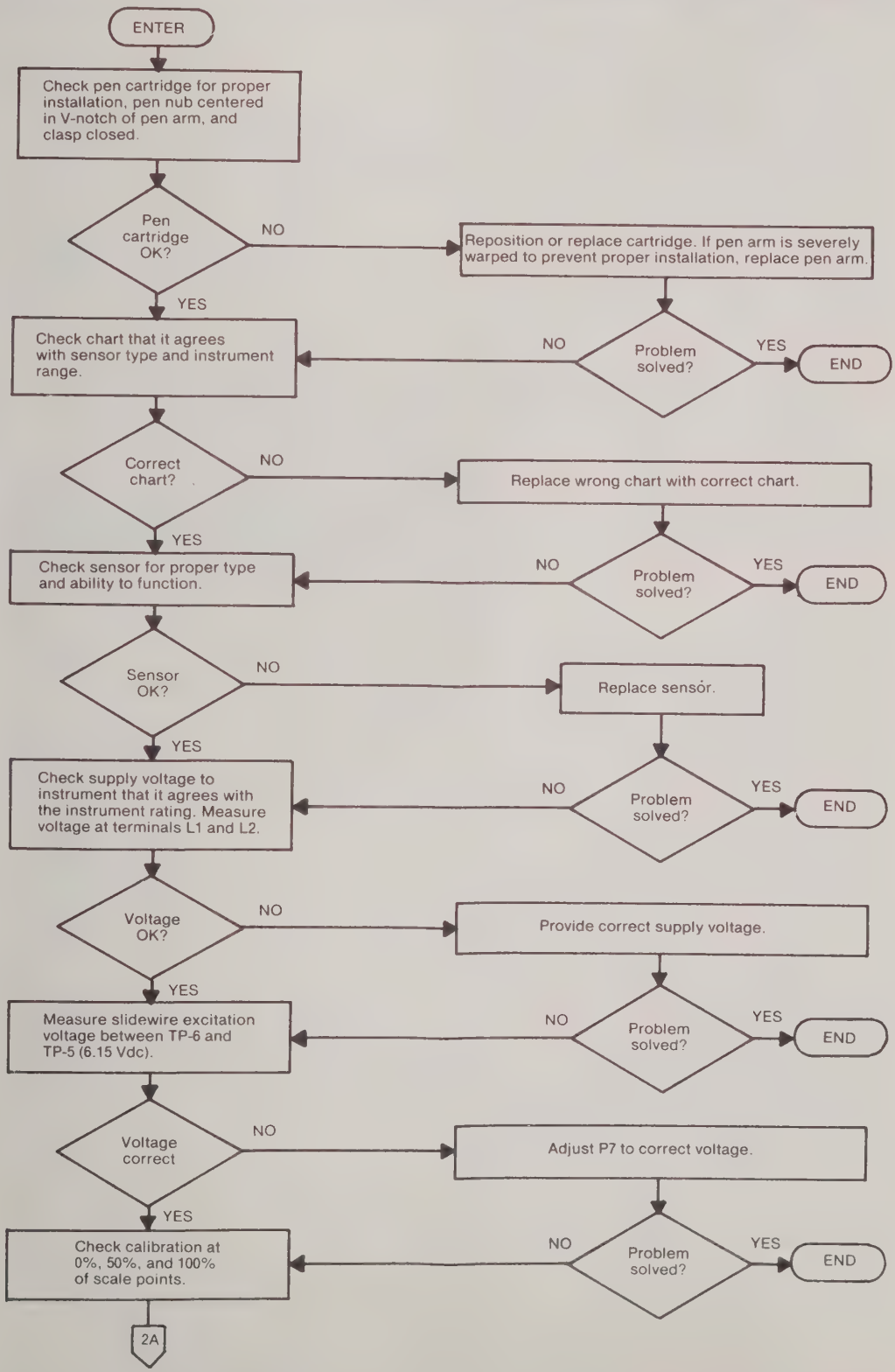
AR 100 Flowchart #1 - Controller will not operate



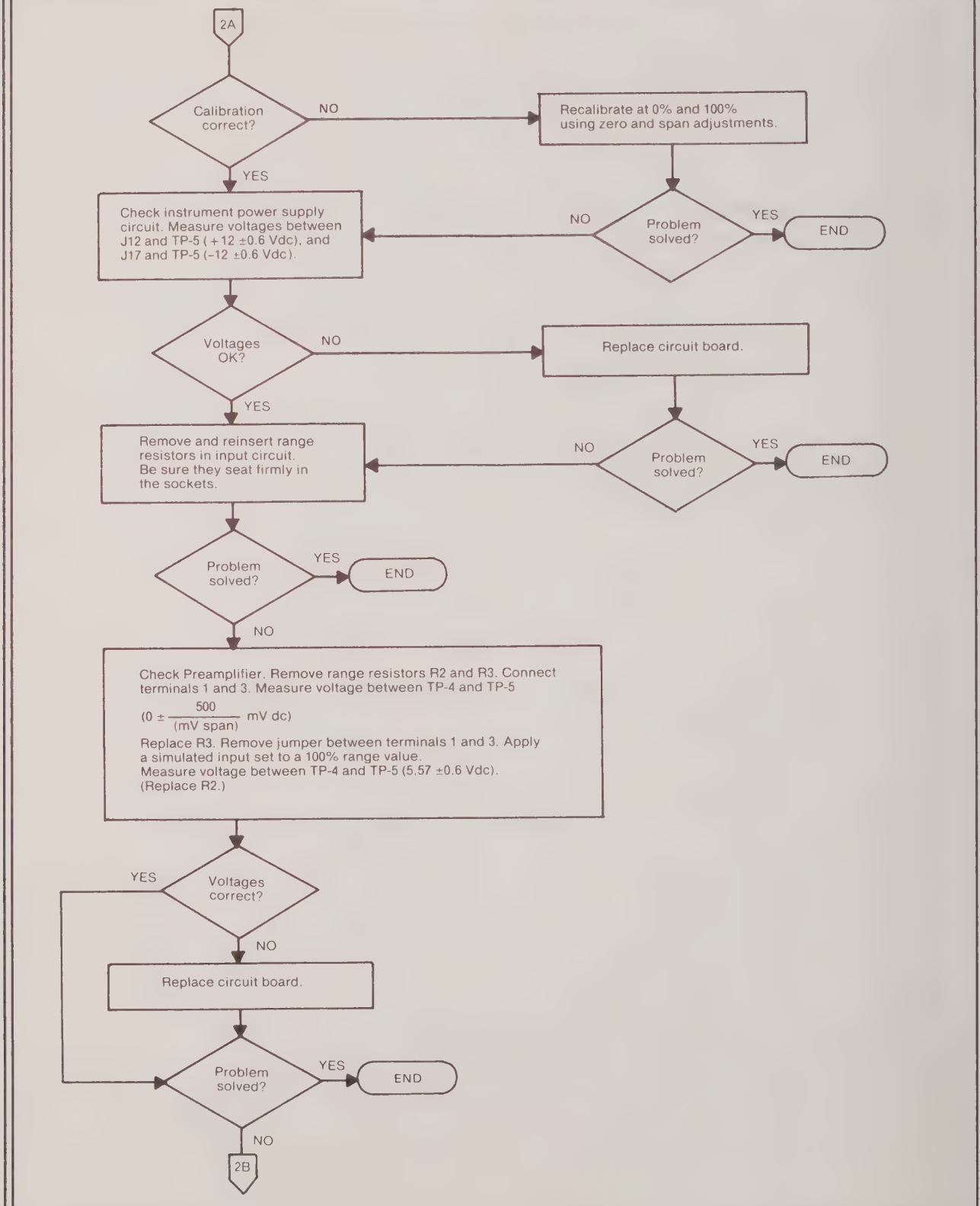
AR 100 Flowchart #1 (continued) (Controller will not operate)



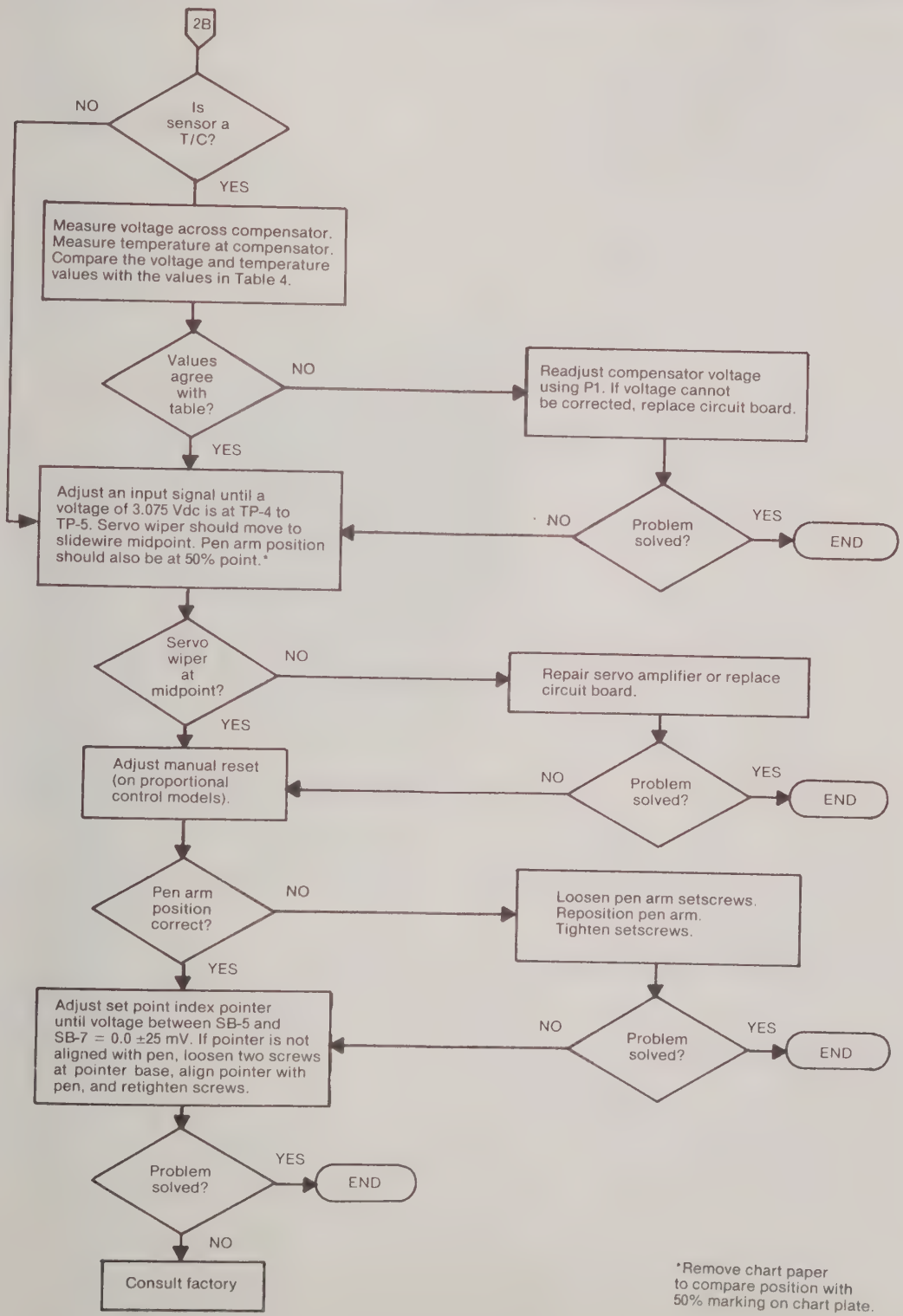
AR 100 Flowchart #2 – Recorder operation normal, but pen trace seems incorrect



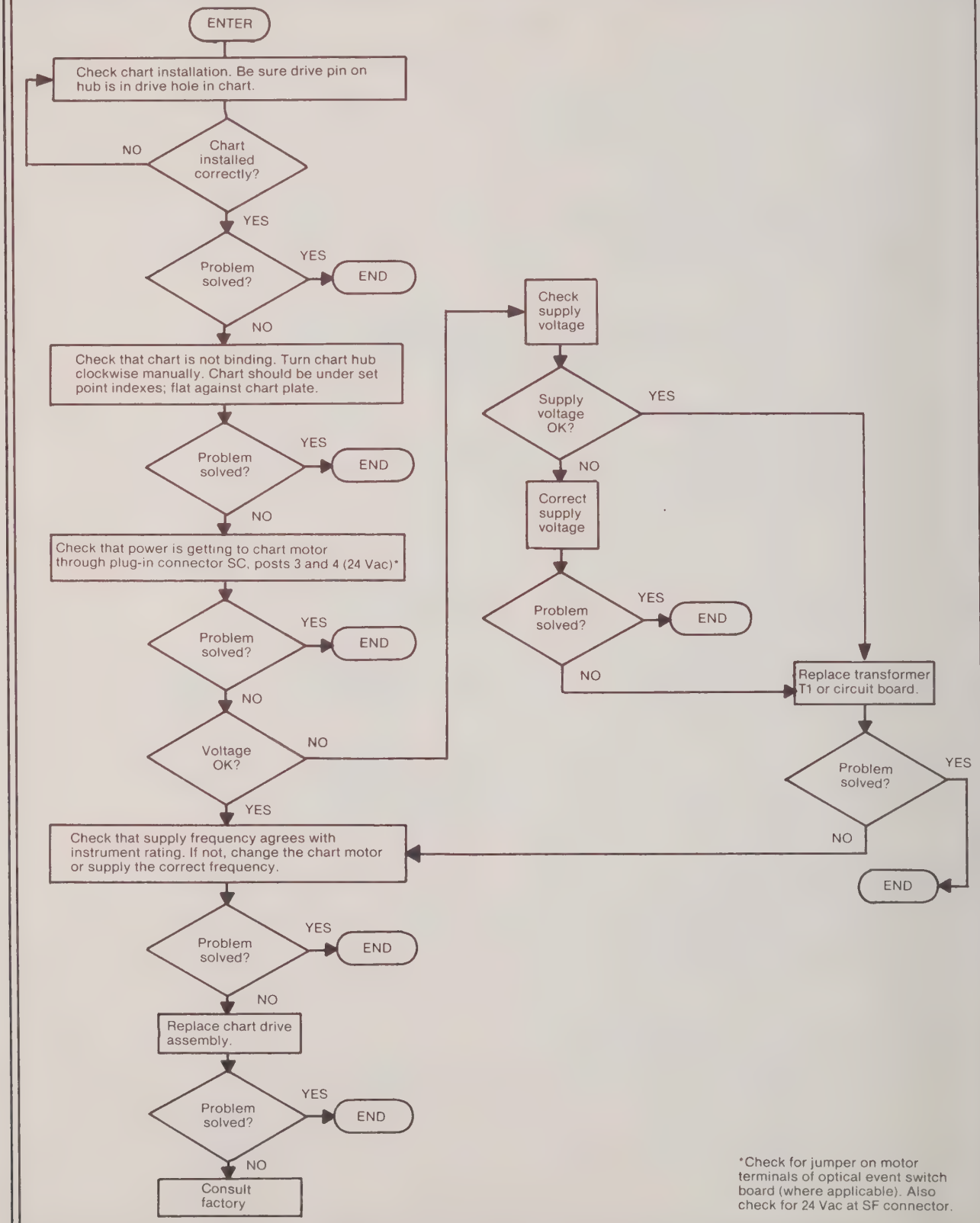
AR 100 Flowchart #2 (continued) (Recorder normal, pen trace incorrect)



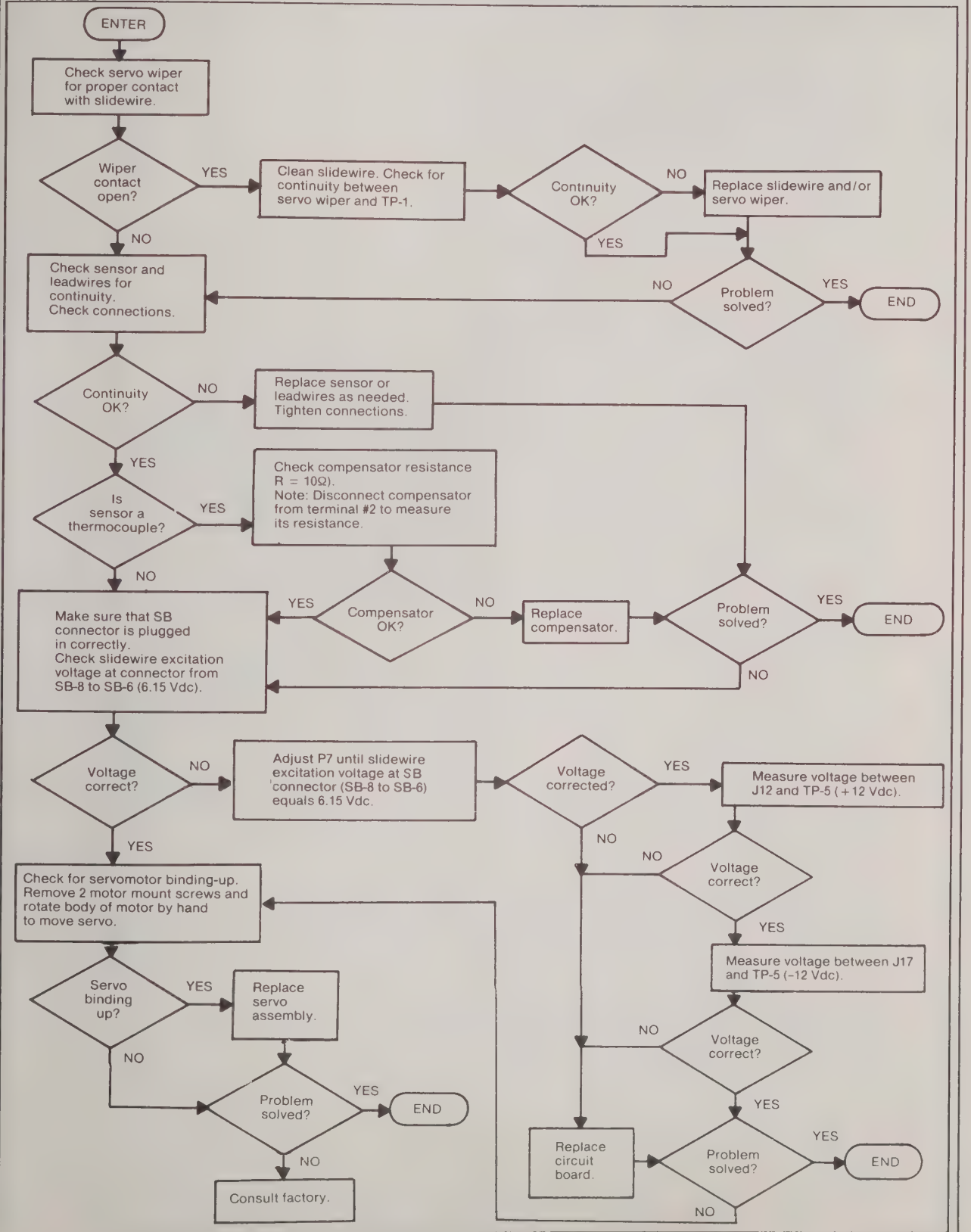
AR 100 Flowchart #2 (continued) (Recorder normal, pen trace incorrect)


2B
Is sensor a T/C?
NO
YES
Measure voltage across compensator. Measure temperature at compensator. Compare the voltage and temperature values with the values in Table 4.
Values agree with table?
NO
Readjust compensator voltage using P1. If voltage cannot be corrected, replace circuit board.
YES
Adjust an input signal until a voltage of 3.075 Vdc is at TP-4 to TP-5. Servo wiper should move to slidewire midpoint. Pen arm position should also be at 50% point.*
NO
Problem solved?
YES
END
Servo wiper at midpoint?
NO
Repair servo amplifier or replace circuit board.
YES
Adjust manual reset (on proportional control models).
NO
Problem solved?
YES
END
Pen arm position correct?
NO
Loosen pen arm setscrews. Reposition pen arm. Tighten setscrews.
YES
Adjust set point index pointer until voltage between SB-5 and SB-7 = 0.0 ±25 mV. If pointer is not aligned with pen, loosen two screws at pointer base, align pointer with pen, and retighten screws.
NO
Problem solved?
YES
END
Problem solved?
YES
END
NO
Consult factory
*Remove chart paper to compare position with 50% marking on chart plate.

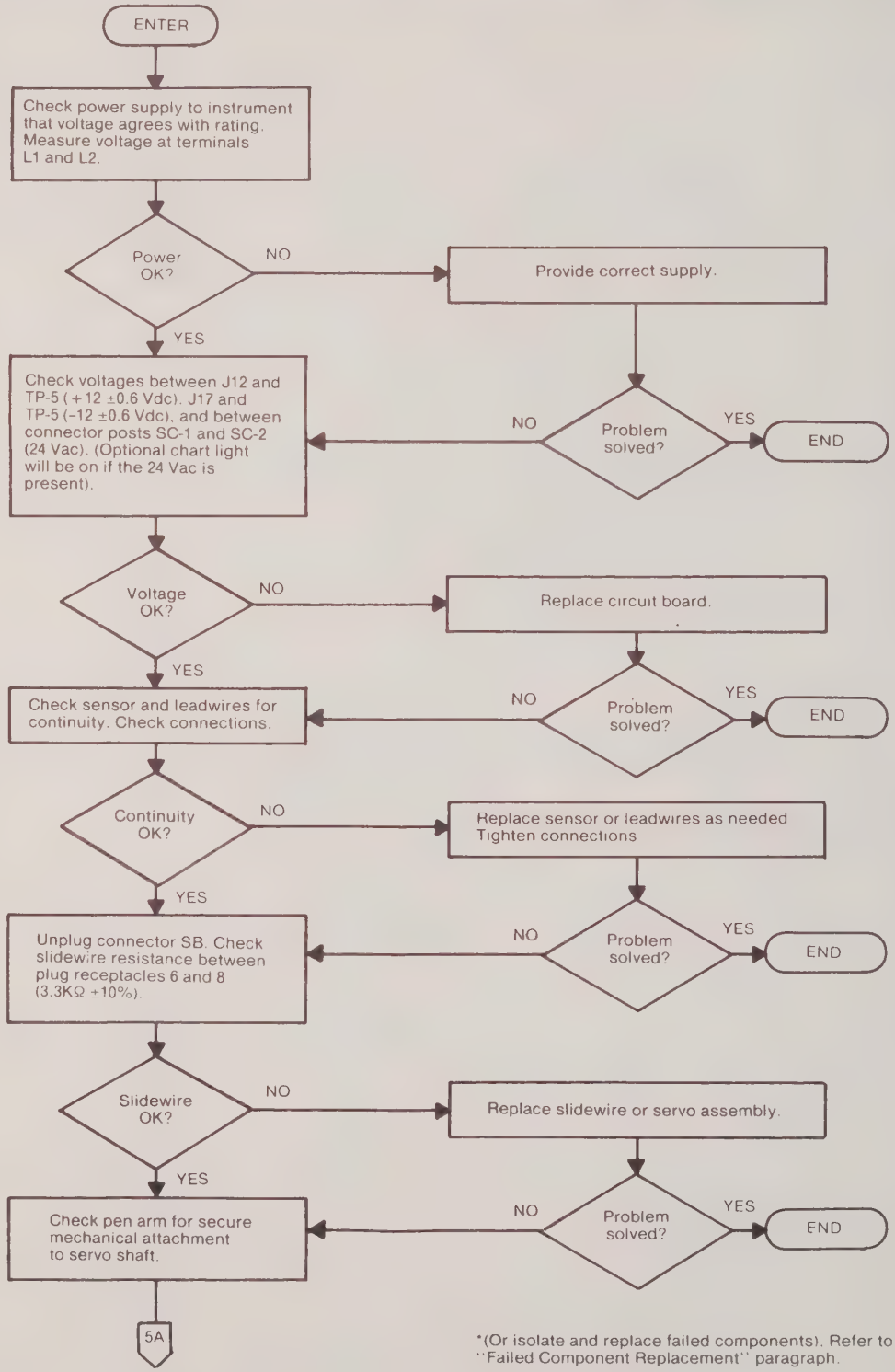
AR 100 Flowchart #3 – Chart rotates at wrong speed or not at all (pen indication correct)



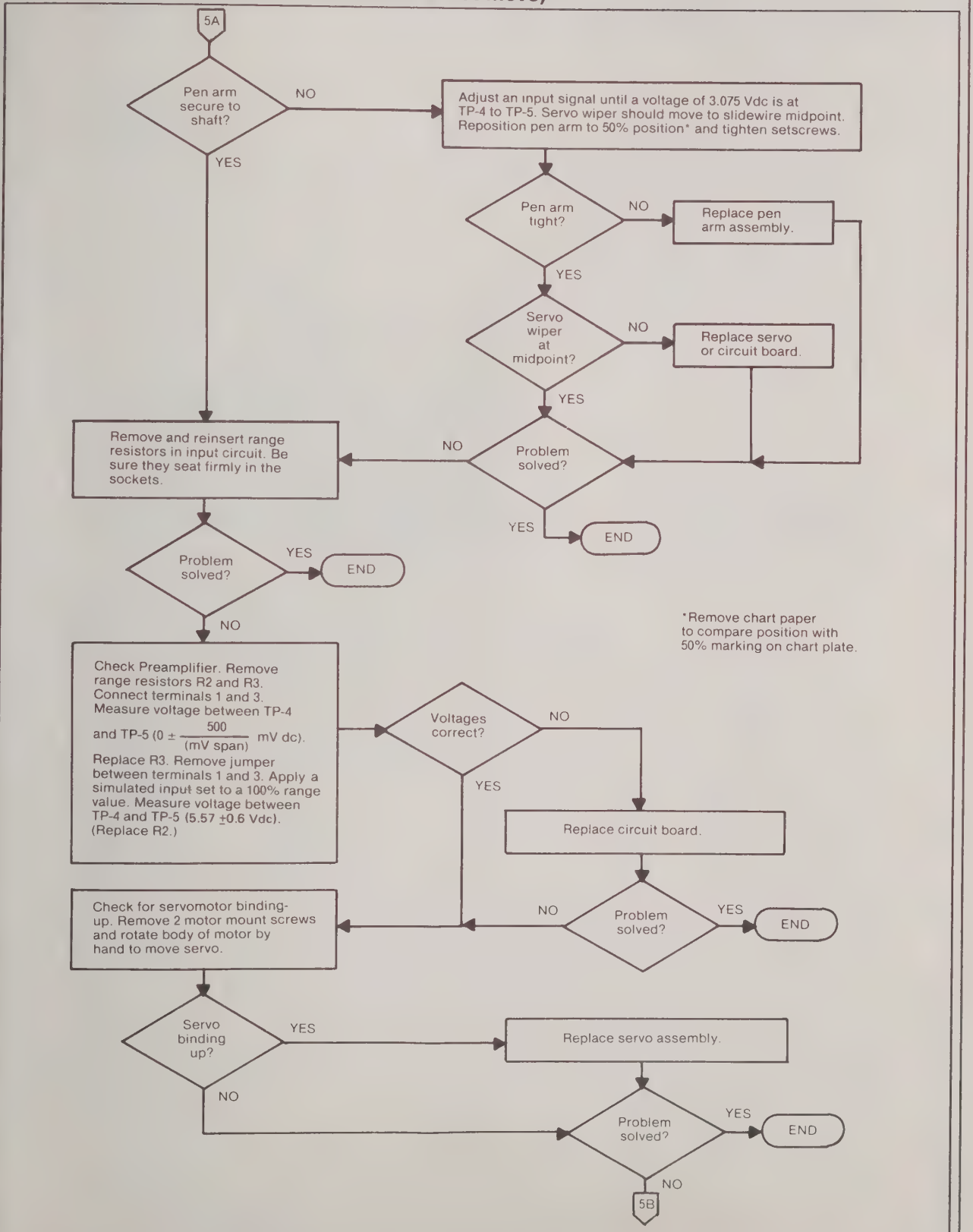
AR 100 Flowchart #4 – Pen remains at high end of chart



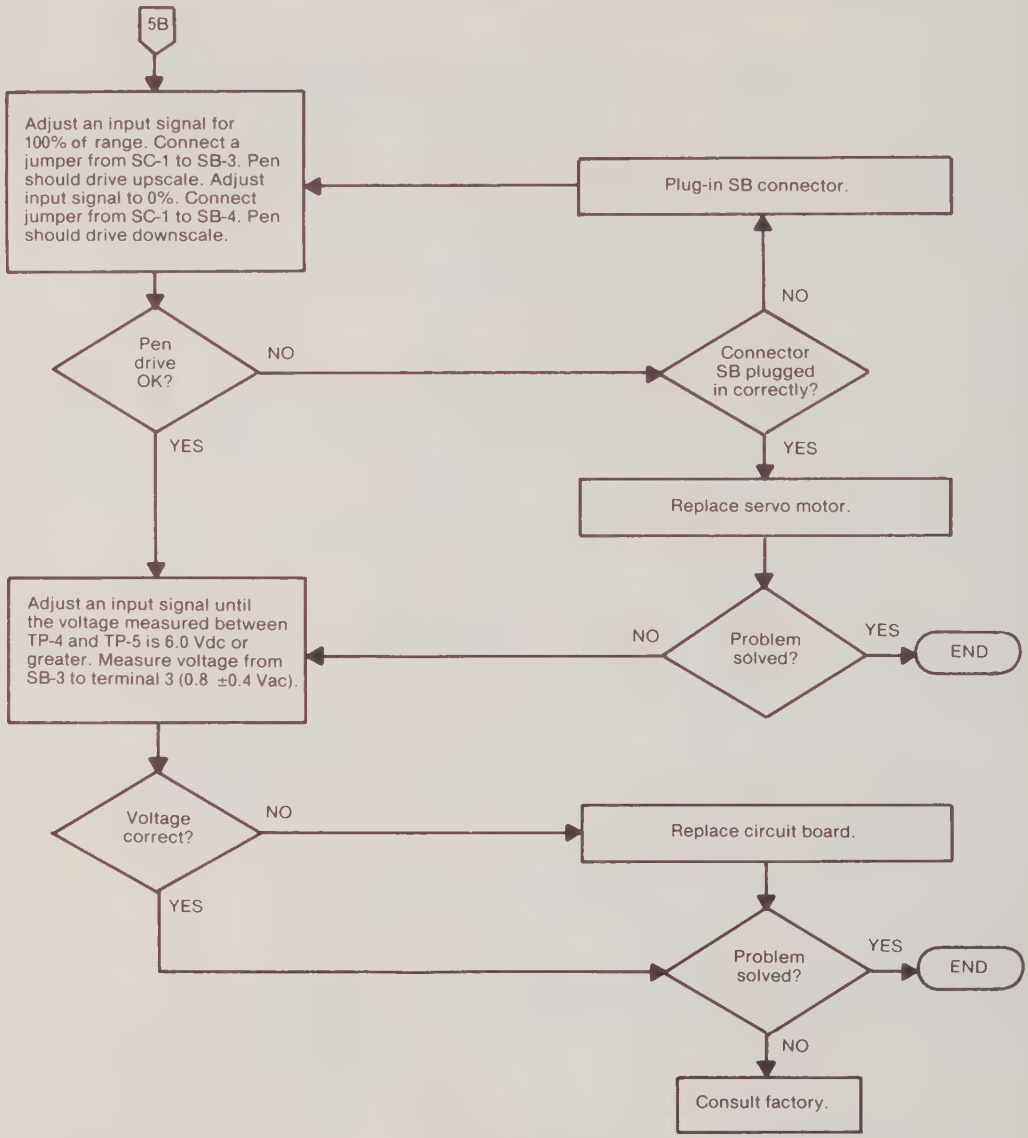
AR 100 Flowchart #5 – Pen will not move regardless of input



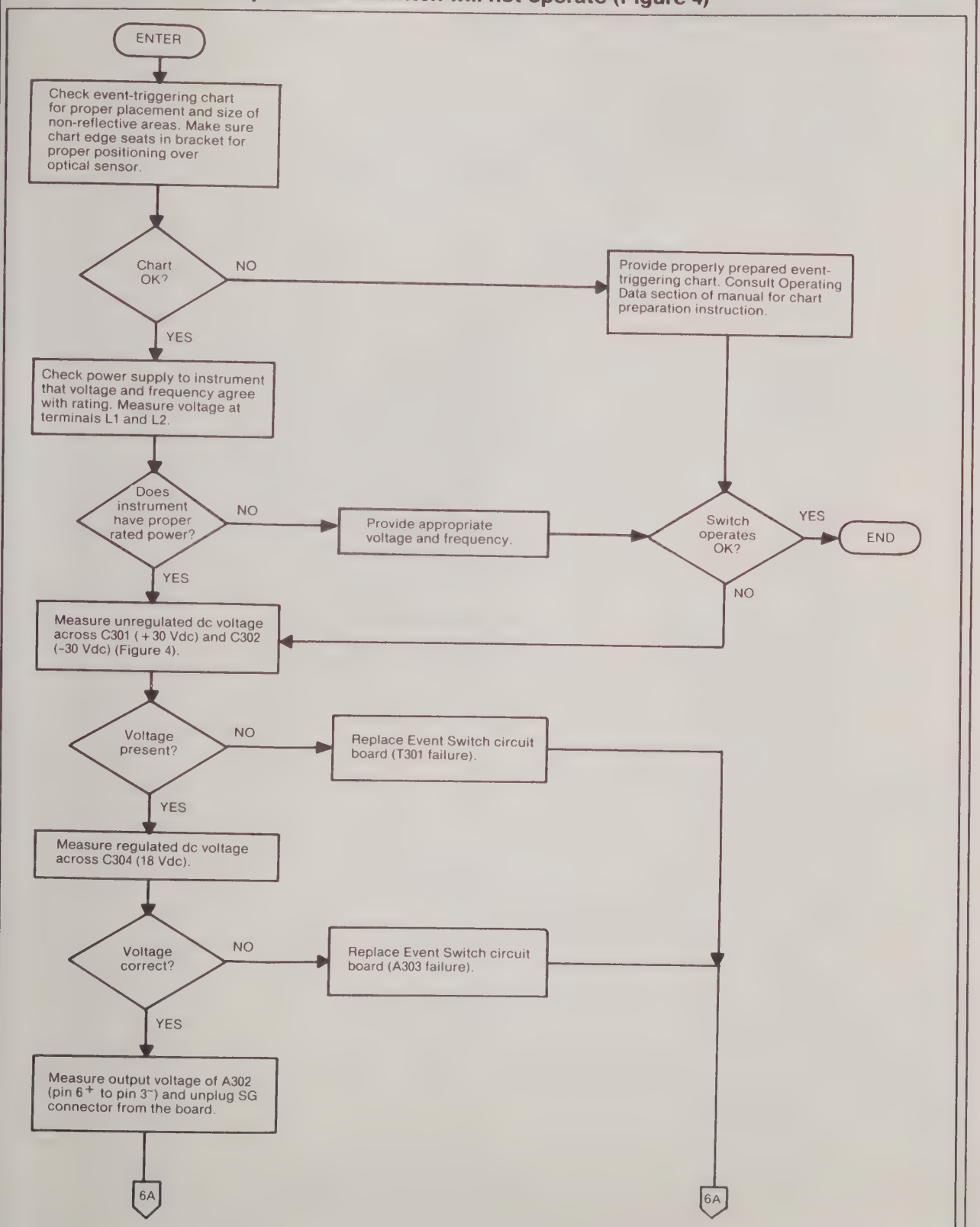
AR 100 Flowchart #5 (continued) (Pen does not move)


5A
Pen arm secure to shaft?
NO
YES
Adjust an input signal until a voltage of 3.075 Vdc is at TP-4 to TP-5. Servo wiper should move to slidewire midpoint. Reposition pen arm to 50% position* and tighten setscrews.
Pen arm tight?
NO
Replace pen arm assembly.
YES
Servo wiper at midpoint?
NO
Replace servo or circuit board.
YES
Problem solved?
NO
YES
END
Remove and reinsert range resistors in input circuit. Be sure they seat firmly in the sockets.
Problem solved?
YES
END
NO
*Remove chart paper to compare position with 50% marking on chart plate.
Check Preamplifier. Remove range resistors R2 and R3. Connect terminals 1 and 3. Measure voltage between TP-4 and TP-5 (0 ± 500/(mV span) mV dc). Replace R3. Remove jumper between terminals 1 and 3. Apply a simulated input set to a 100% range value. Measure voltage between TP-4 and TP-5 (5.57 ±0.6 Vdc). (Replace R2.)
Voltages correct?
NO
YES
Replace circuit board.
Problem solved?
NO
YES
END
Check for servomotor binding-up. Remove 2 motor mount screws and rotate body of motor by hand to move servo.
Servo binding up?
YES
Replace servo assembly.
NO
Problem solved?
YES
END
NO
5B

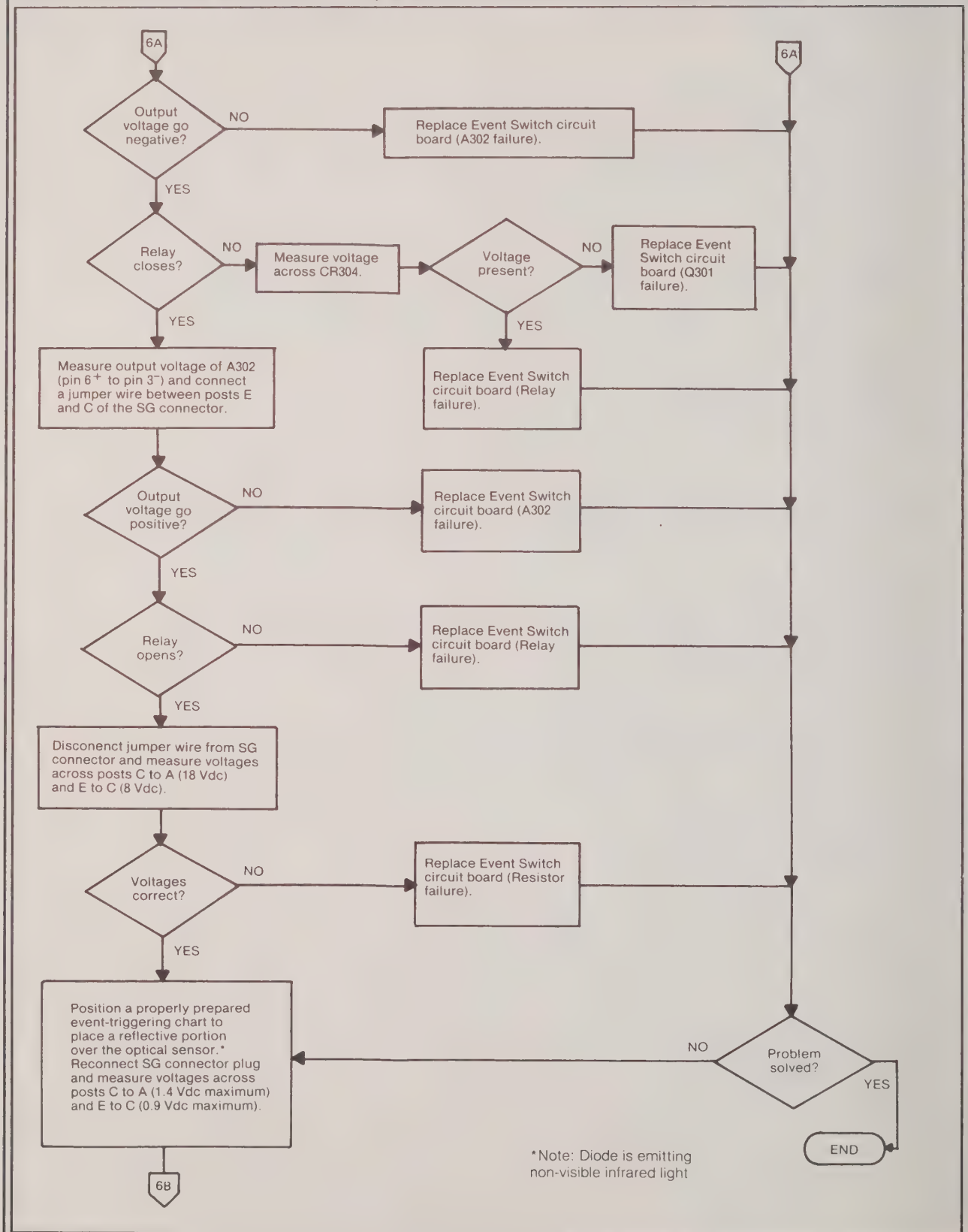
AR 100 Flowchart #5 (continued) (Pen does not move)


5B
Adjust an input signal for 100% of range. Connect a jumper from SC-1 to SB-3. Pen should drive upscale. Adjust input signal to 0%. Connect jumper from SC-1 to SB-4. Pen should drive downscale.
Plug-in SB connector.
NO
Pen drive OK?
NO
Connector SB plugged in correctly?
YES
YES
Replace servo motor.
Adjust an input signal until the voltage measured between TP-4 and TP-5 is 6.0 Vdc or greater. Measure voltage from SB-3 to terminal 3 (0.8 ±0.4 Vac).
NO
Problem solved?
YES
END
Voltage correct?
NO
Replace circuit board.
YES
Problem solved?
YES
END
NO
Consult factory.

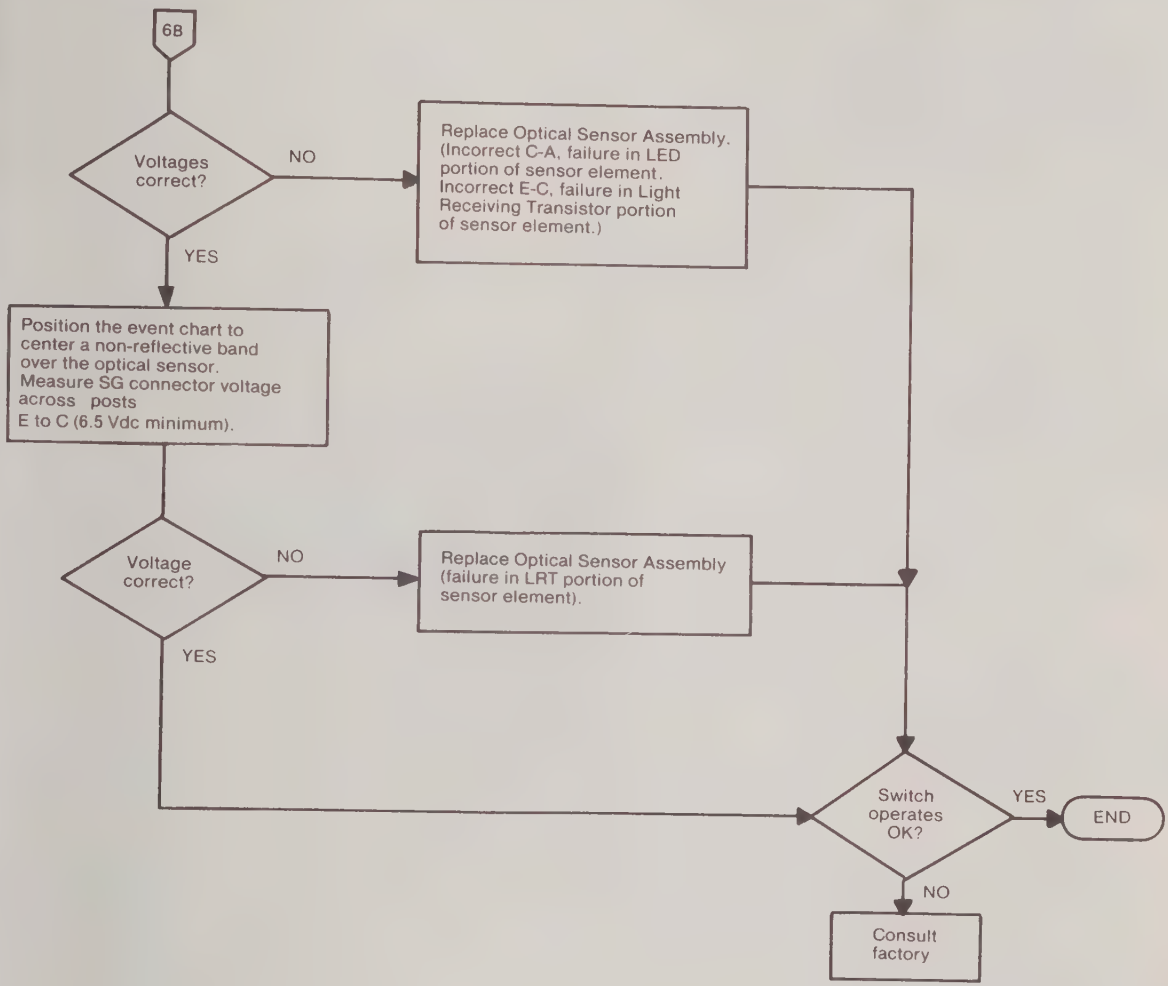
AR 100 Flowchart #6 – Optical event switch will not operate (Figure 4)


ENTER
Check event-triggering chart for proper placement and size of non-reflective areas. Make sure chart edge seats in bracket for proper positioning over optical sensor.
Chart OK?
NO
Provide properly prepared event-triggering chart. Consult Operating Data section of manual for chart preparation instruction.
YES
Check power supply to instrument that voltage and frequency agree with rating. Measure voltage at terminals L1 and L2.
Does instrument have proper rated power?
NO
Provide appropriate voltage and frequency.
Switch operates OK?
YES
END
NO
YES
Measure unregulated dc voltage across C301 (+30 Vdc) and C302 (-30 Vdc) (Figure 4).
Voltage present?
NO
Replace Event Switch circuit board (T301 failure).
YES
Measure regulated dc voltage across C304 (18 Vdc).
Voltage correct?
NO
Replace Event Switch circuit board (A303 failure).
YES
Measure output voltage of A302 (pin 6+ to pin 3−) and unplug SG connector from the board.
6A
6A

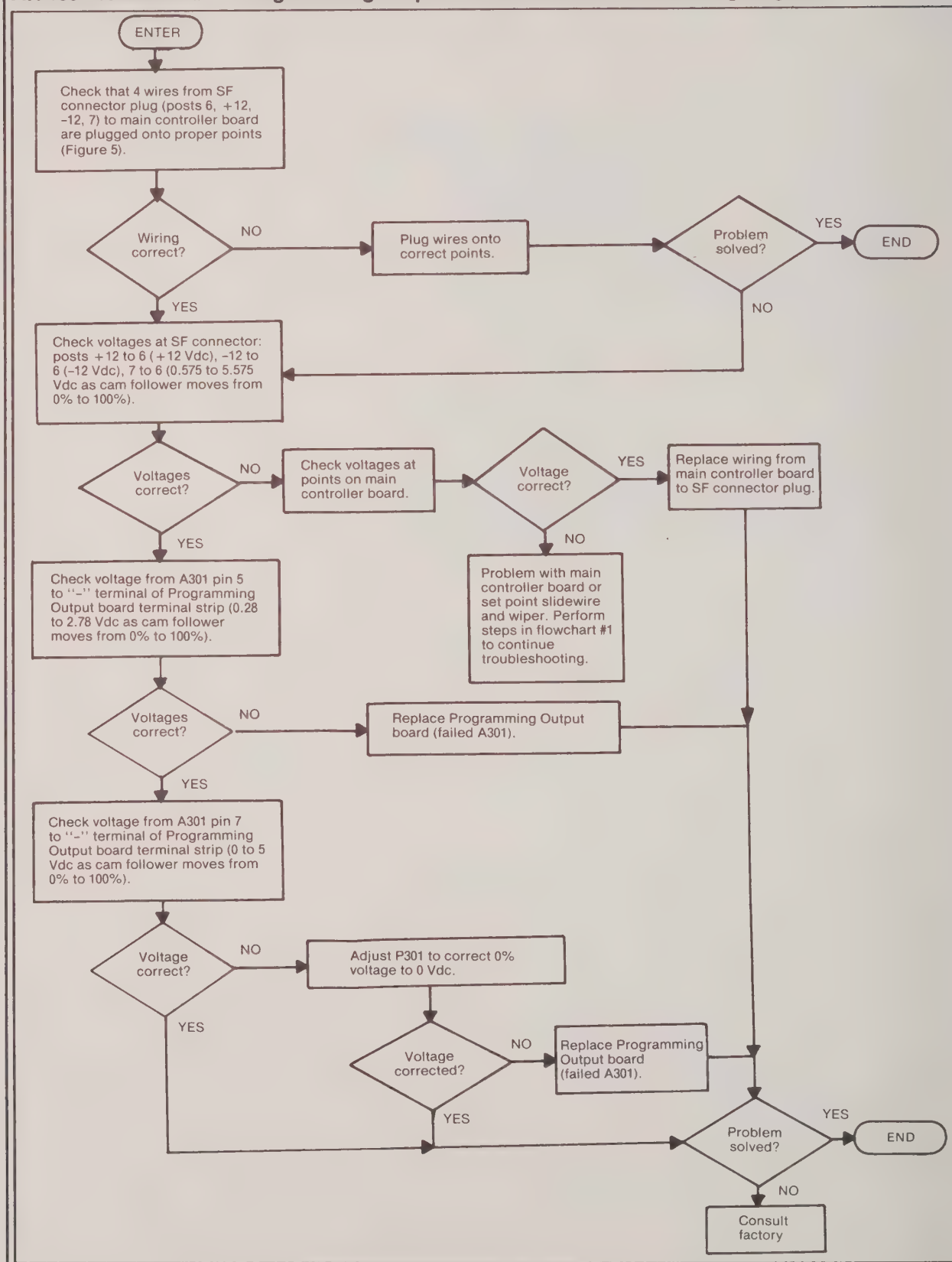
AR 100 Flowchart #6 (continued) - Optical event switch will not operate (Figure 4)


6A
Output voltage go negative?
NO
Replace Event Switch circuit board (A302 failure).
6A
YES
Relay closes?
NO
Measure voltage across CR304.
Voltage present?
NO
Replace Event Switch circuit board (Q301 failure).
YES
YES
Measure output voltage of A302 (pin 6+ to pin 3−) and connect a jumper wire between posts E and C of the SG connector.
Replace Event Switch circuit board (Relay failure).
Output voltage go positive?
NO
Replace Event Switch circuit board (A302 failure).
YES
Relay opens?
NO
Replace Event Switch circuit board (Relay failure).
YES
Disconenct jumper wire from SG connector and measure voltages across posts C to A (18 Vdc) and E to C (8 Vdc).
Voltages correct?
NO
Replace Event Switch circuit board (Resistor failure).
YES
Position a properly prepared event-triggering chart to place a reflective portion over the optical sensor.* Reconnect SG connector plug and measure voltages across posts C to A (1.4 Vdc maximum) and E to C (0.9 Vdc maximum).
NO
Problem solved?
YES
END
6B
*Note: Diode is emitting non-visible infrared light

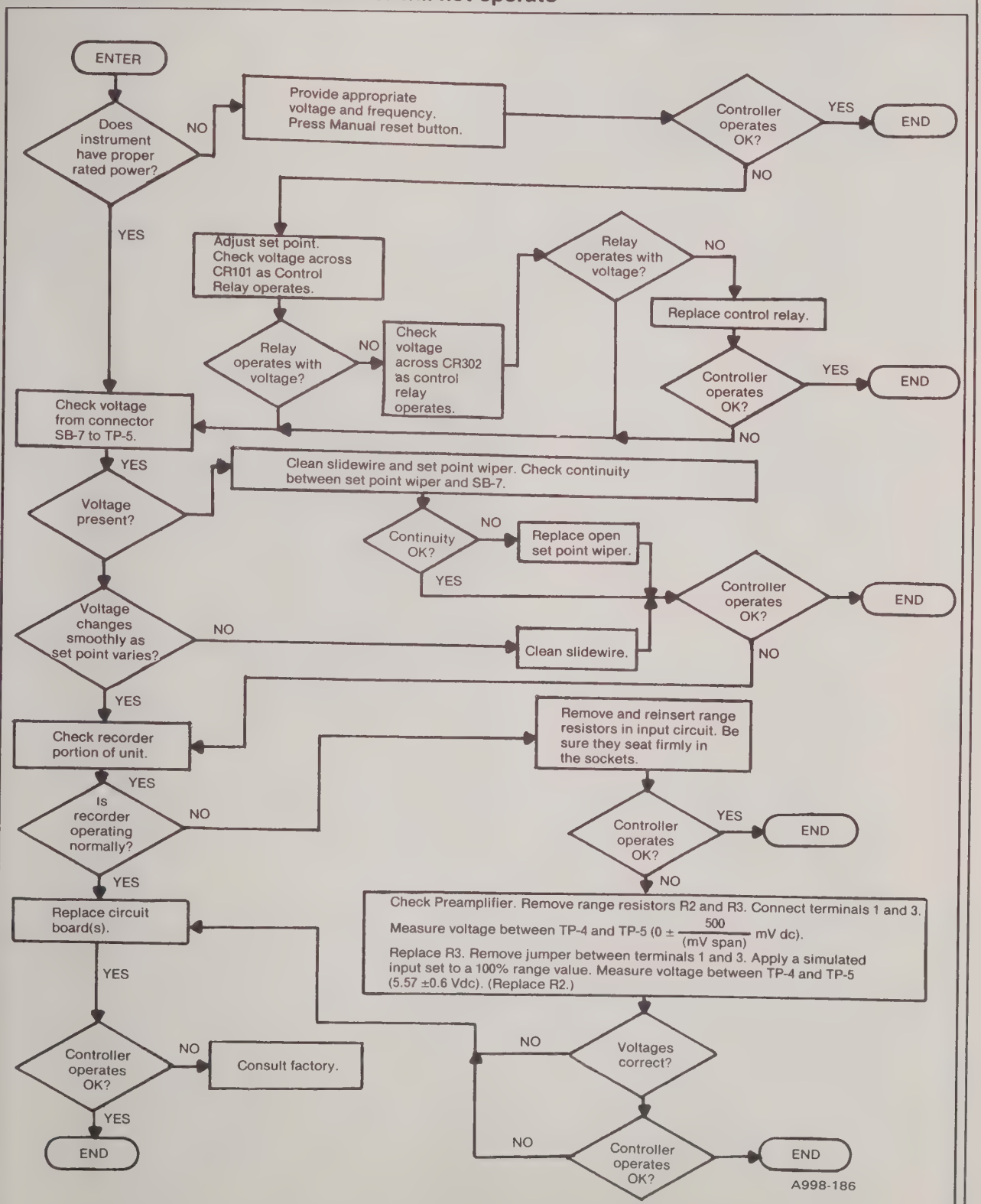
Flowchart #6 (continued) – Optical event switch will not operate (Figure 4)


6B
Voltages correct?
NO
Replace Optical Sensor Assembly. (Incorrect C-A, failure in LED portion of sensor element. Incorrect E-C, failure in Light Receiving Transistor portion of sensor element.)
YES
Position the event chart to center a non-reflective band over the optical sensor. Measure SG connector voltage across posts E to C (6.5 Vdc minimum).
Voltage correct?
NO
Replace Optical Sensor Assembly (failure in LRT portion of sensor element).
YES
Switch operates OK?
YES
END
NO
Consult factory

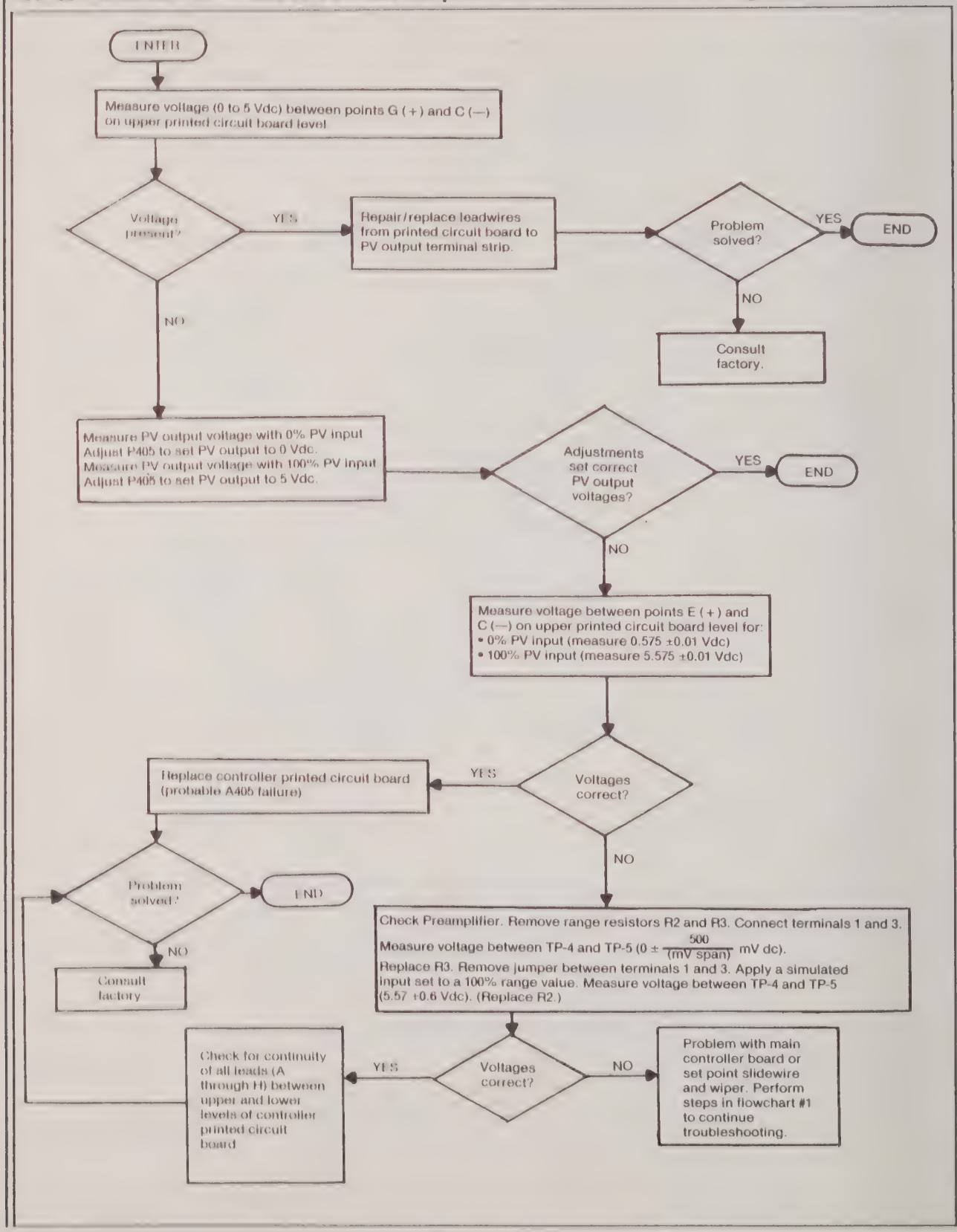
AR 100 Flowchart #7 - Programming output incorrect or not functioning (Figure 4)


ENTER
Check that 4 wires from SF connector plug (posts 6, +12, -12, 7) to main controller board are plugged onto proper points (Figure 5).
Wiring correct?
NO
Plug wires onto correct points.
Problem solved?
YES
END
NO
YES
Check voltages at SF connector: posts +12 to 6 (+12 Vdc), -12 to 6 (-12 Vdc), 7 to 6 (0.575 to 5.575 Vdc as cam follower moves from 0% to 100%).
Voltages correct?
NO
Check voltages at points on main controller board.
Voltage correct?
YES
Replace wiring from main controller board to SF connector plug.
NO
YES
Check voltage from A301 pin 5 to "-" terminal of Programming Output board terminal strip (0.28 to 2.78 Vdc as cam follower moves from 0% to 100%).
Problem with main controller board or set point slidewire and wiper. Perform steps in flowchart #1 to continue troubleshooting.
Voltages correct?
NO
Replace Programming Output board (failed A301).
YES
Check voltage from A301 pin 7 to "-" terminal of Programming Output board terminal strip (0 to 5 Vdc as cam follower moves from 0% to 100%).
Voltage correct?
NO
Adjust P301 to correct 0% voltage to 0 Vdc.
YES
Voltage corrected?
NO
Replace Programming Output board (failed A301).
YES
Problem solved?
YES
END
NO
Consult factory

AR 100 Flowchart #8 – Limit Controller will not operate



AR 100 Flowchart #9 – Process Variable Output Incorrect or not functioning (Figure 7)


ENTER
Measure voltage (0 to 5 Vdc) between points G (+) and C (—) on upper printed circuit board level
Voltage present?
YES
Repair/replace leadwires from printed circuit board to PV output terminal strip.
Problem solved?
YES
END
NO
Consult factory.
NO
Measure PV output voltage with 0% PV input
Adjust P405 to set PV output to 0 Vdc.
Measure PV output voltage with 100% PV input
Adjust P405 to set PV output to 5 Vdc.
Adjustments set correct PV output voltages?
YES
END
NO
Measure voltage between points E (+) and C (—) on upper printed circuit board level for:
• 0% PV input (measure 0.575 ±0.01 Vdc)
• 100% PV input (measure 5.575 ±0.01 Vdc)
Voltages correct?
YES
Replace controller printed circuit board (probable A405 failure)
Problem solved?
END
NO
Consult factory
NO
Check Preamplifier. Remove range resistors R2 and R3. Connect terminals 1 and 3.
Measure voltage between TP-4 and TP-5 (0 ± 500/(mV span) mV dc).
Replace R3. Remove jumper between terminals 1 and 3. Apply a simulated input set to a 100% range value. Measure voltage between TP-4 and TP-5 (5.57 ±0.6 Vdc). (Replace R2.)
Voltages correct?
YES
Check for continuity of all leads (A through H) between upper and lower levels of controller printed circuit board
NO
Problem with main controller board or set point slidewire and wiper. Perform steps in flowchart #1 to continue troubleshooting.

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Failed Component Replacement

Board replacement is generally preferrable to component replacement because of possible soldering damage to a board and because of variations in replacement components. However, it is not always possible to obtain the desired replacement board immediately, and the following procedure may be performed.

CAUTION: Use a low power soldering iron (30 watts maximum) and a solder suction tool or solder wick material to remove solder from required points. Be careful not to overheat copper pads while melting the solder. Be careful not to allow solder to "bridge over" between component attachment points when re-soldering components into place.

Isolate failed components in accordance with standard troubleshooting procedures. (Schematic circuit diagrams are included at the end of this section as well as in the Technical Data section 44-01-05-01). Unplug wiring connectors from the front of the board, remove wiring from terminals, and remove the 6 screws holding the board in the case.

After board repair, replace it in the case with the 6 screws. Replace wiring to terminals as previously connected, and plug wiring connectors onto the board as before. (Connection points are shown in the upper portion of Figure 4.)

For supply voltage failures indicated in troubleshooting flowchart #5, replace:

- T1 if 24 Vac supply voltage (SC-1 to SC-2) is not correct.
- T2 if unregulated dc supply voltages (≈+24 Vdc from the plus end of C12 to TP5; ≈−24 Vdc from the minus end of C15 to TP5) are not correct.[a]
- A2 if regulated voltages (+12 ±0.6 Vdc; −12 ±0.6 Vdc) at measured points (J12 to TP5, plus; J17 to TP5, minus) are equally incorrect.
- A3 and Q1 if measurement of regulated voltages shows the positive voltage correct but the negative voltage incorrect.

[a]Additional components which should be checked and/or replaced before T2 are CR3, CR4, CR5, CR6; C12, and C15. T2 is OK if ac voltage is present at the rectifier diodes (refer to power supply schematic).

Components may be obtained by ordering the following Honeywell part numbers:

Component	Part Number
T1 (100/24)	24001161-008
T1 (120/24)	24001161-003
T1 (230/24)	24001161-004
T2 (100/37)[b]	24001161-009
T2 (120/37)[b]	24001161-005
T2 (230/37)[b]	24001161-006
CR3, 4, 5, 6 (1N645)	122144
C12, 15 (100 μF, 50V)	24001191-001
A2 (UA 78M12 C)	24001184-451
A3 (LM 307 C)	24001482-451
Q1 (GE D43C2)	134941

[b](center-tapped)

Consult the Parts List section of the manual for additional ordering information.

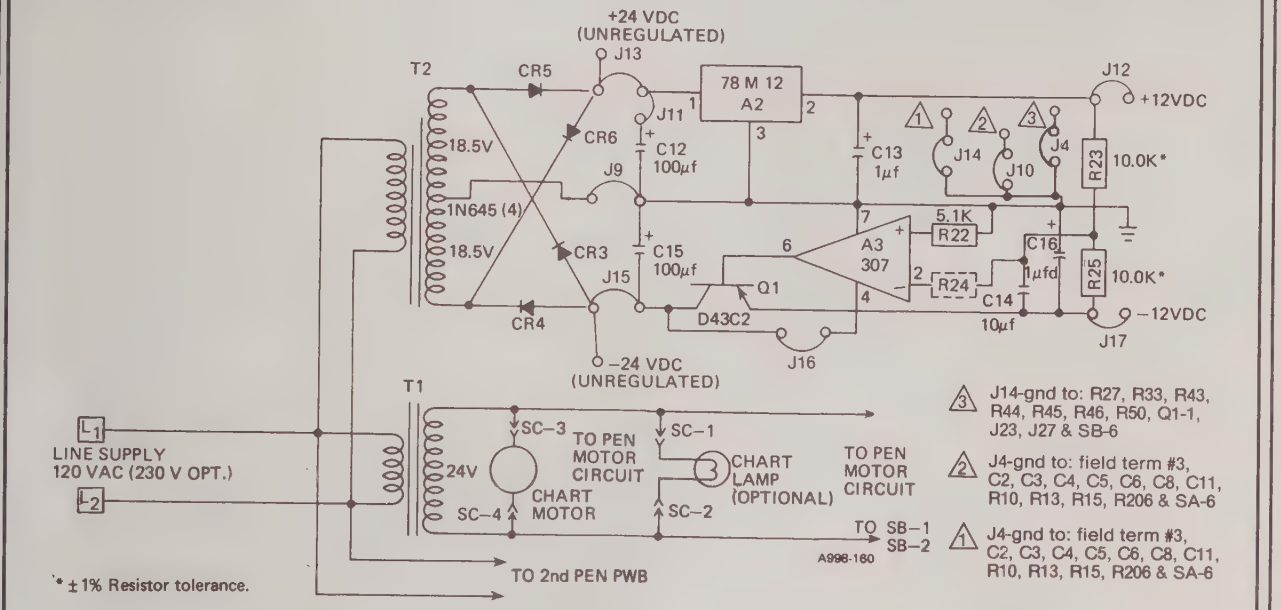


Figure 8 – Power Supply

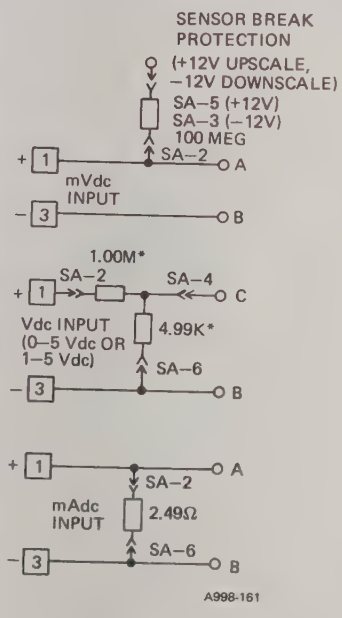


Figure 9 – mV dc, Vdc mA dc Input

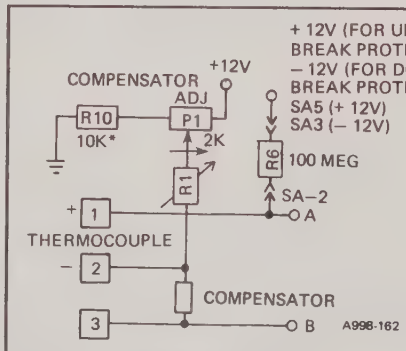


Figure 10 – Thermocouple Input

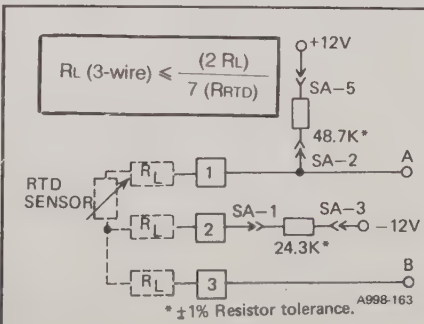


Figure 11 – RTD Input

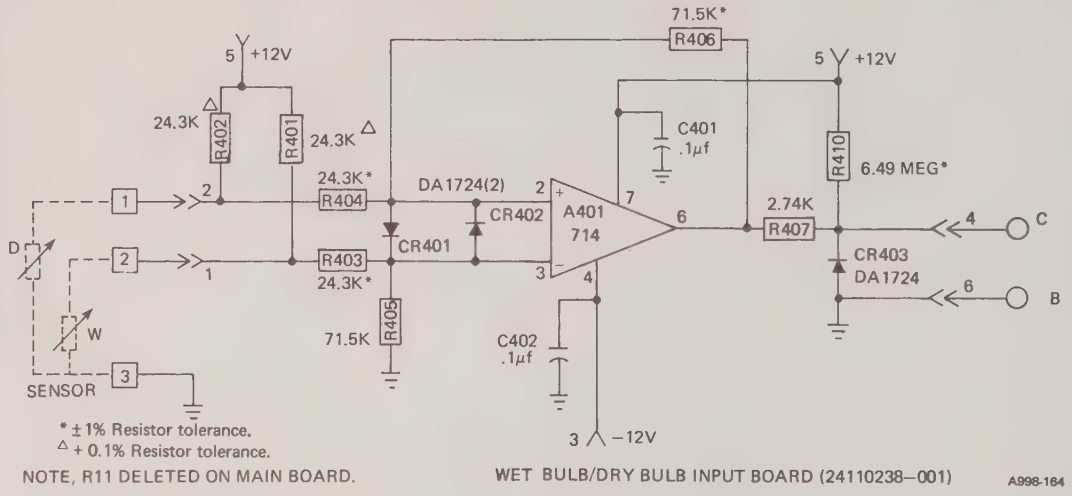


Figure 12 – ΔRTD Input

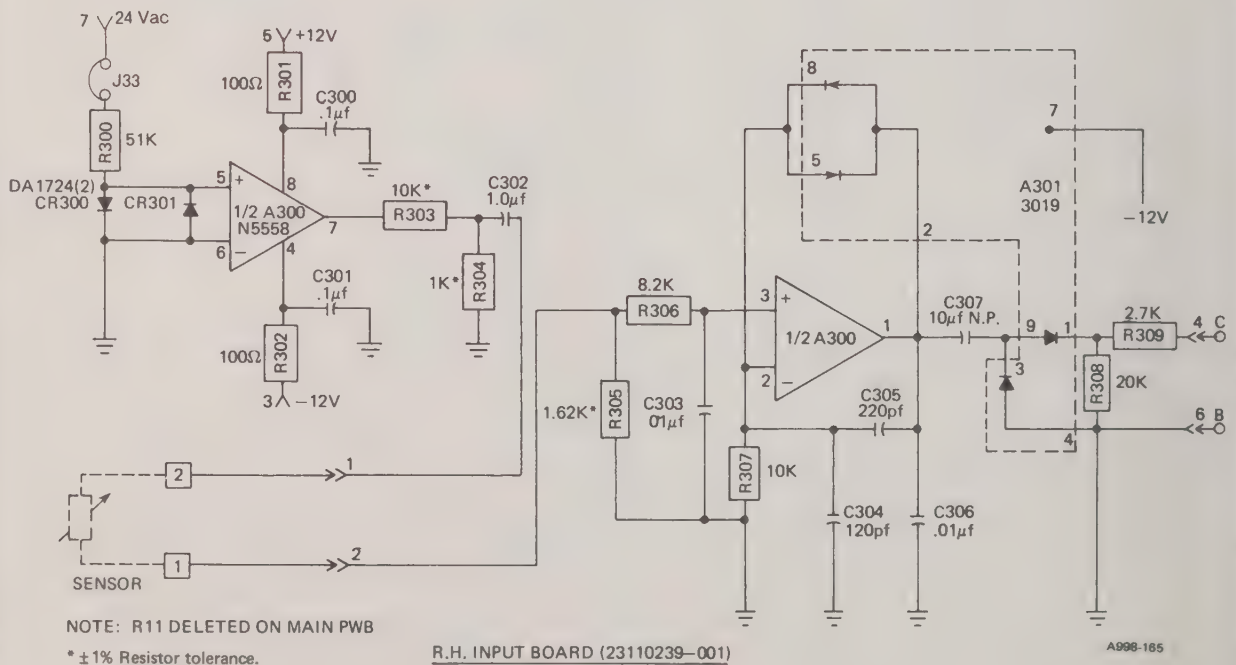


Figure 13 – RH Sensor Input

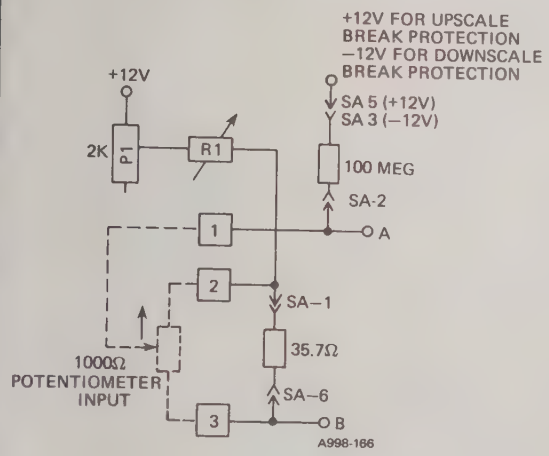


Figure 14 – Potentiometer/Slidewire Input

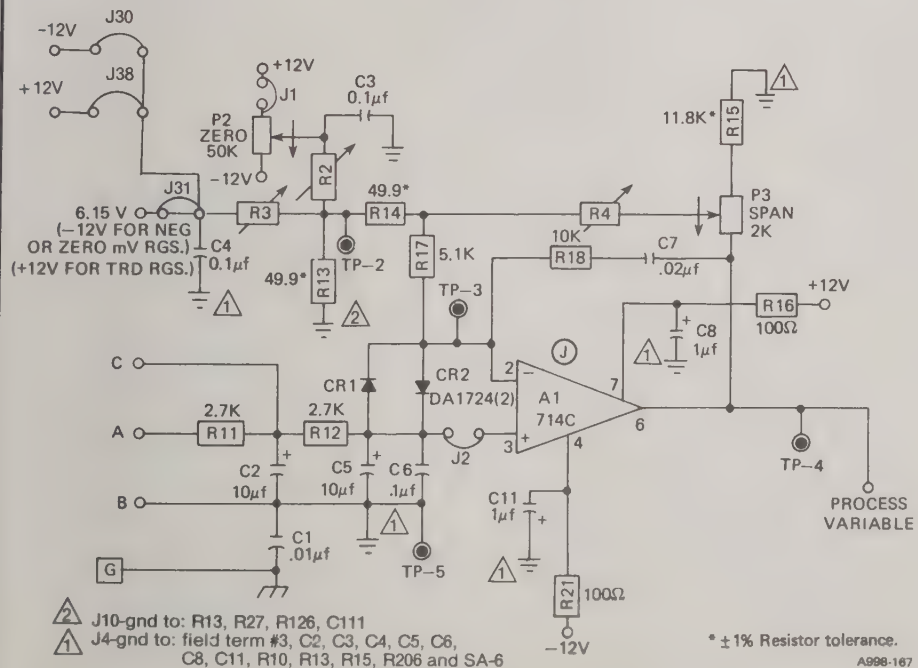


Figure 15 – Measuring Circuit and Pre-Amplifier

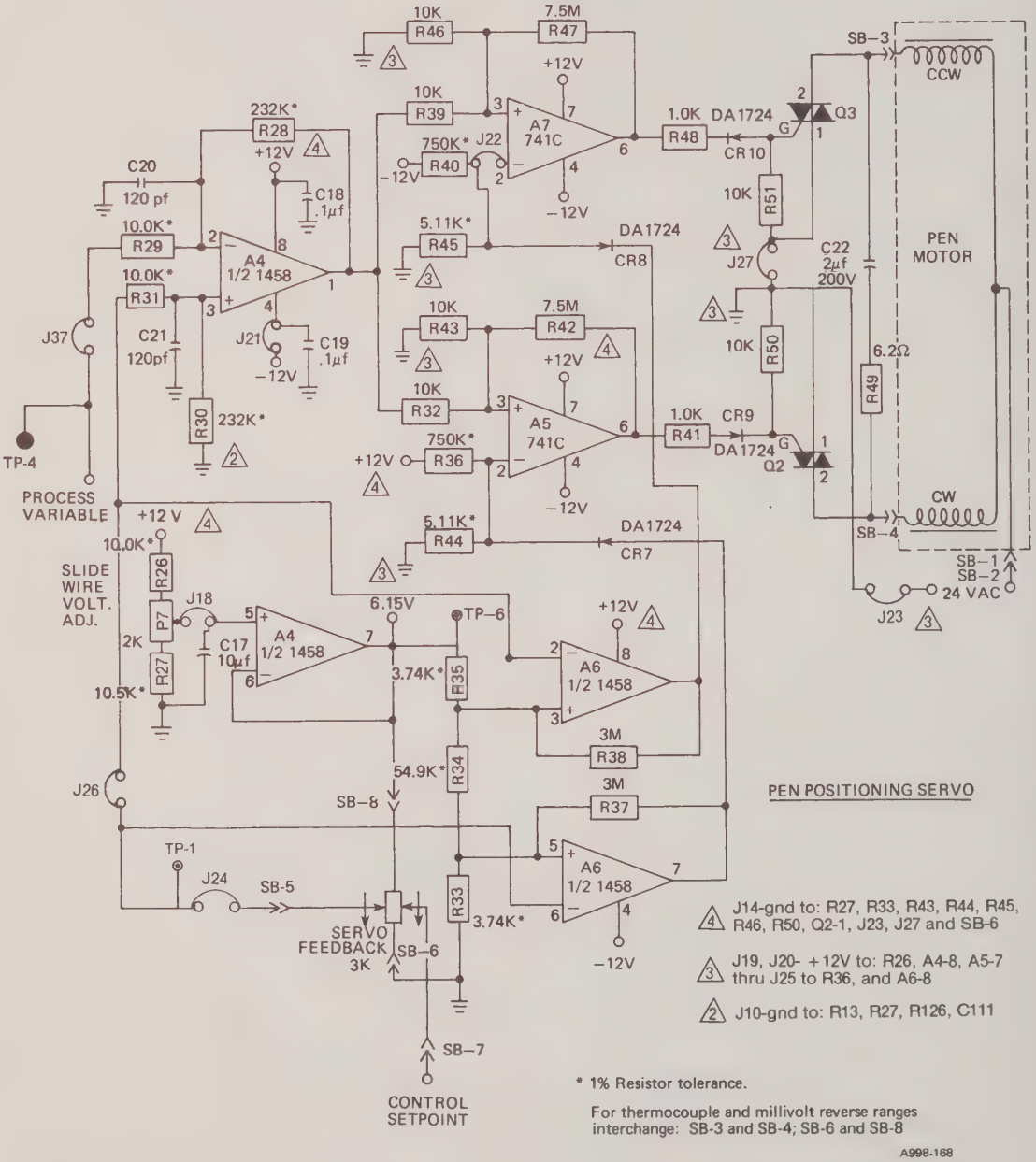


Figure 16 – Pen Positioning Servo

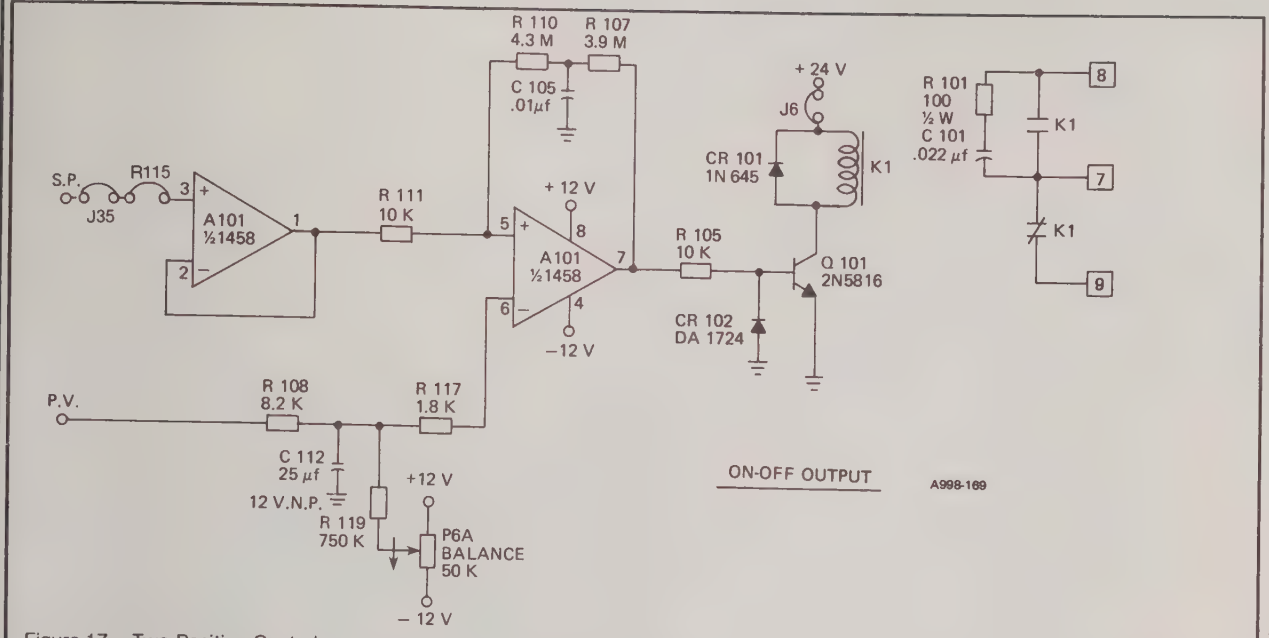


Figure 17 – Two-Position Control

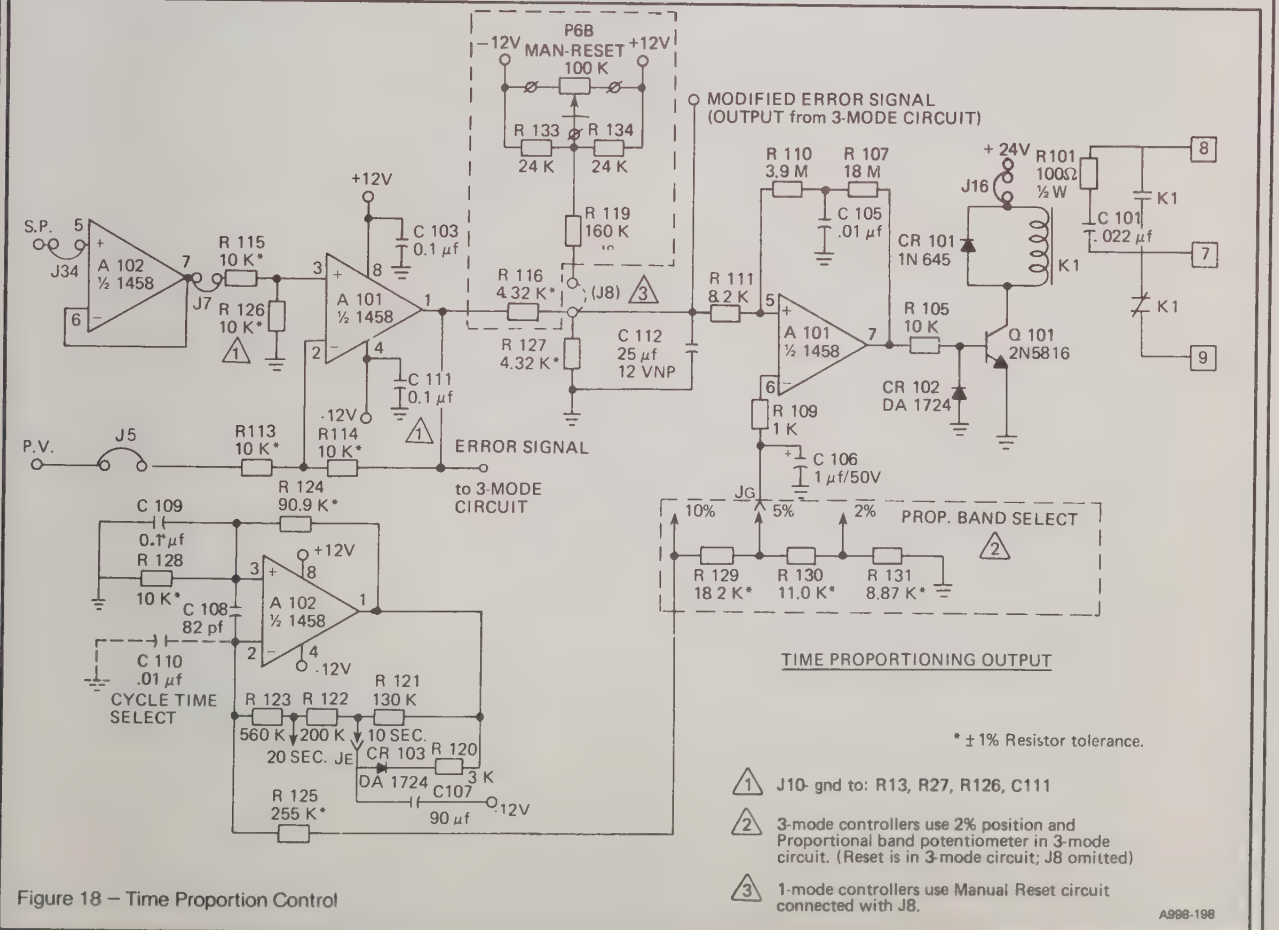


Figure 18 – Time Proportion Control

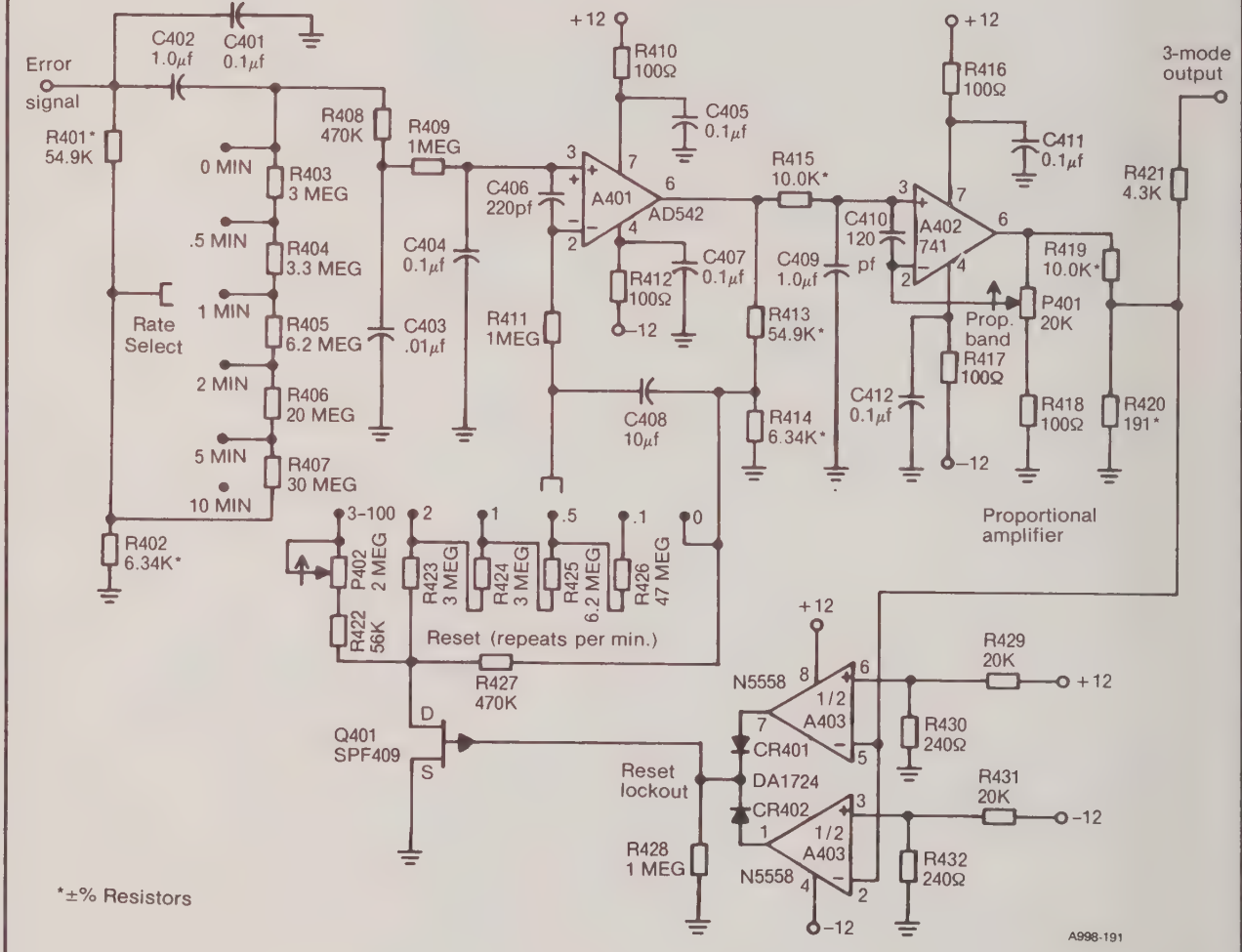


Figure 19 – Three Mode Circuit

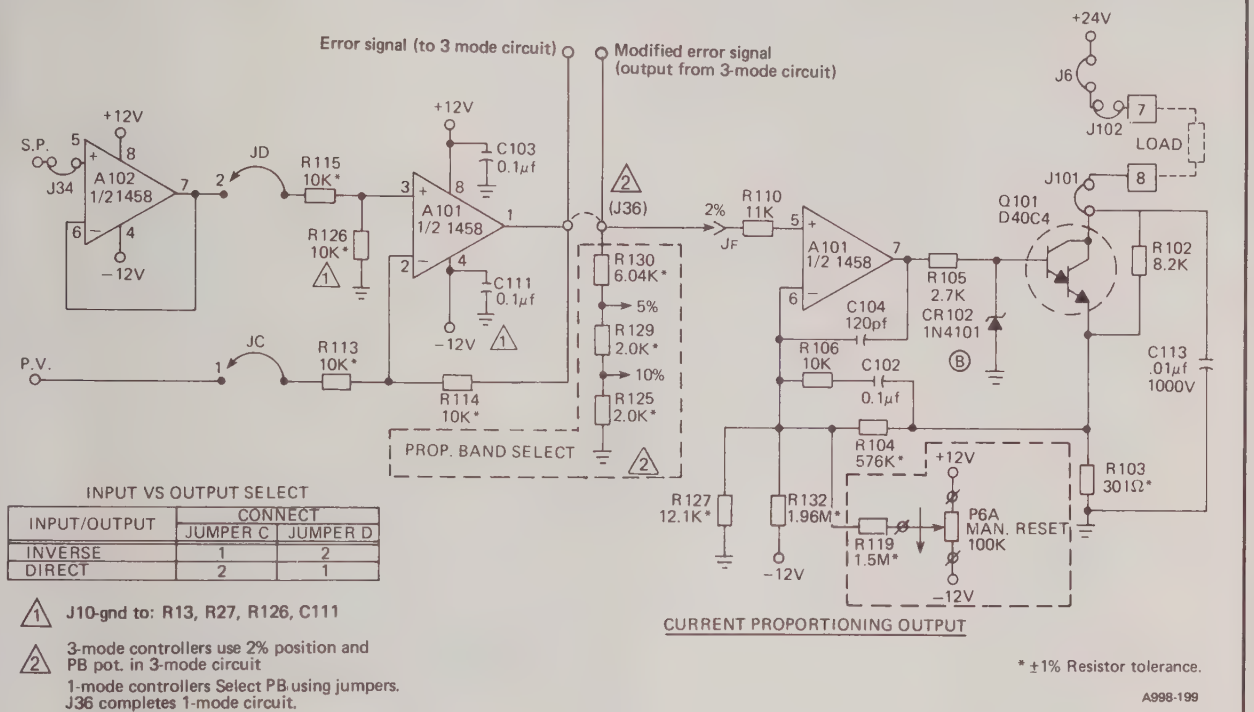
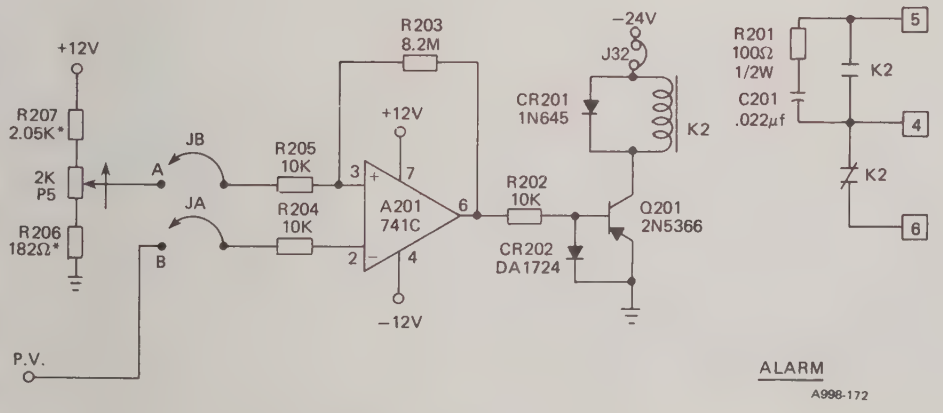


Figure 20 – Current Proportion Control



RELAY ENERGIZED FOR	CONNECT	
	JUMPER B	JUMPER A
P.V. ABOVE ALARM S.P.	A	B
P.V. BELOW ALARM S.P.	B	A

Figure 21 – Process Alarm Circuit

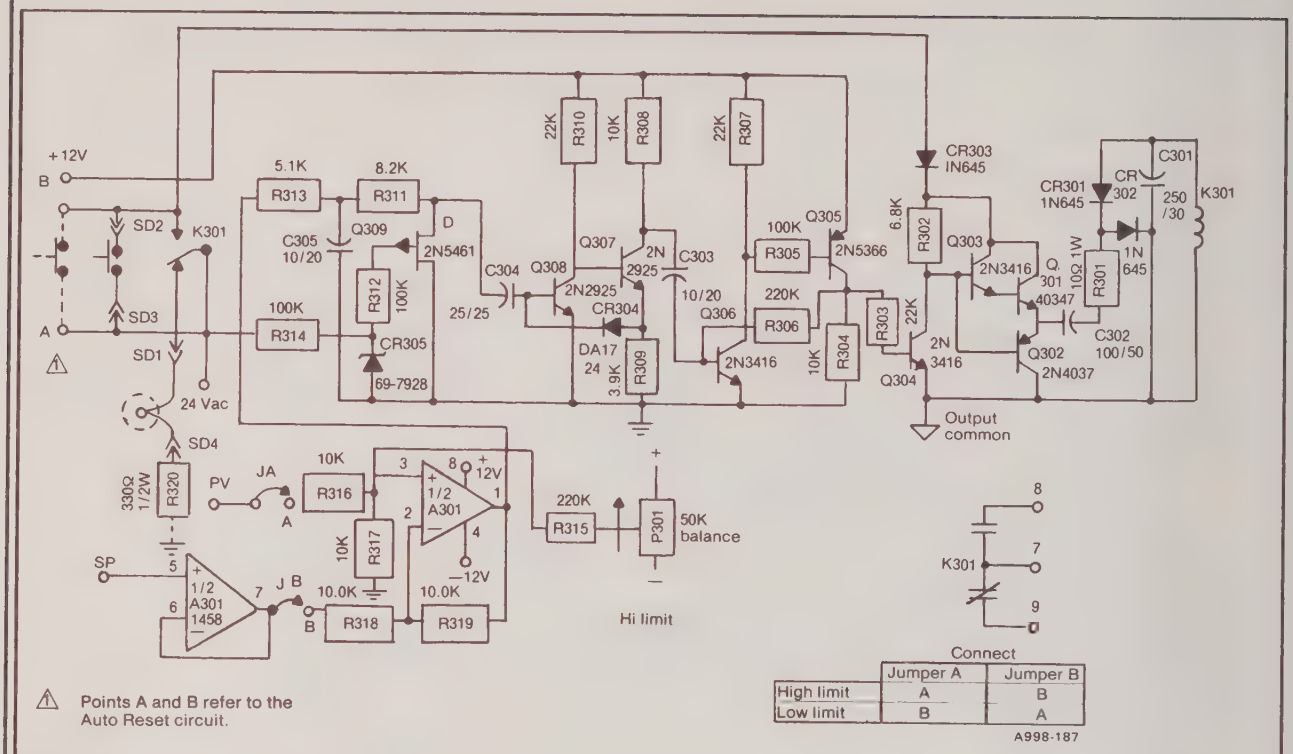


Figure 22 – High (Low) Limit Circuit

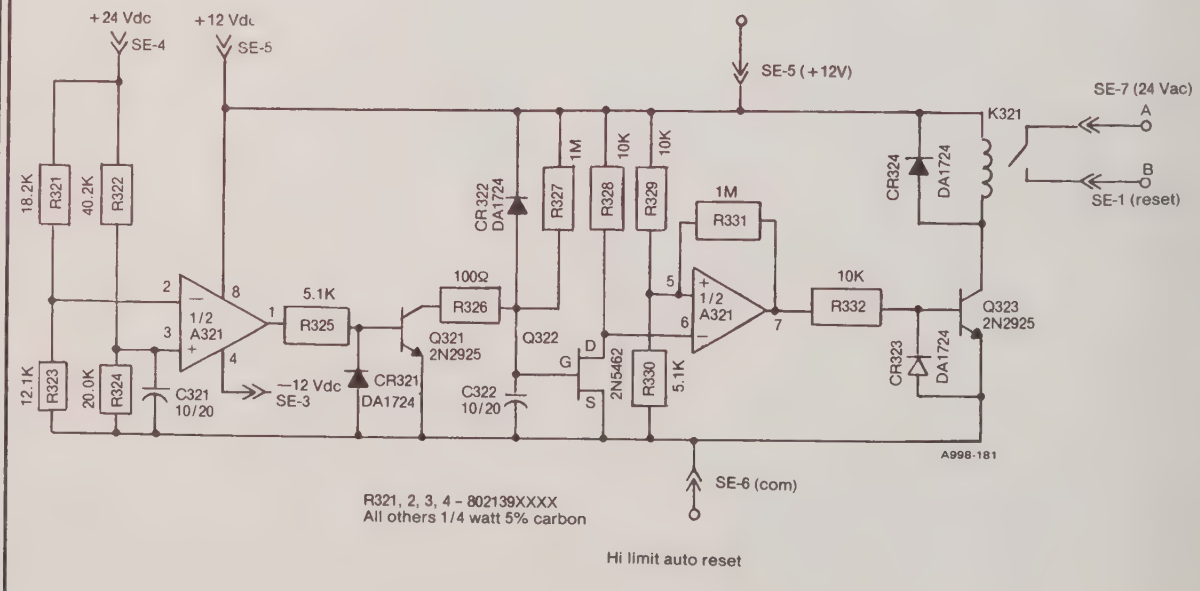


Figure 23 – Auto-Reset Circuit

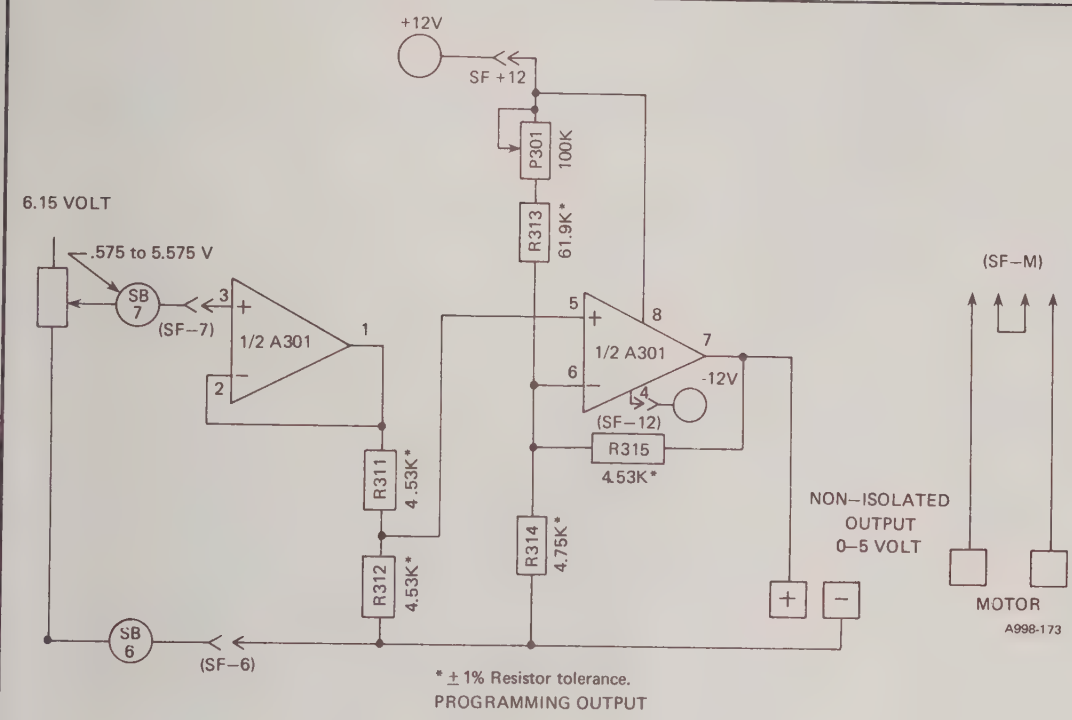


Figure 24 – Program Output (Remote Set Point)

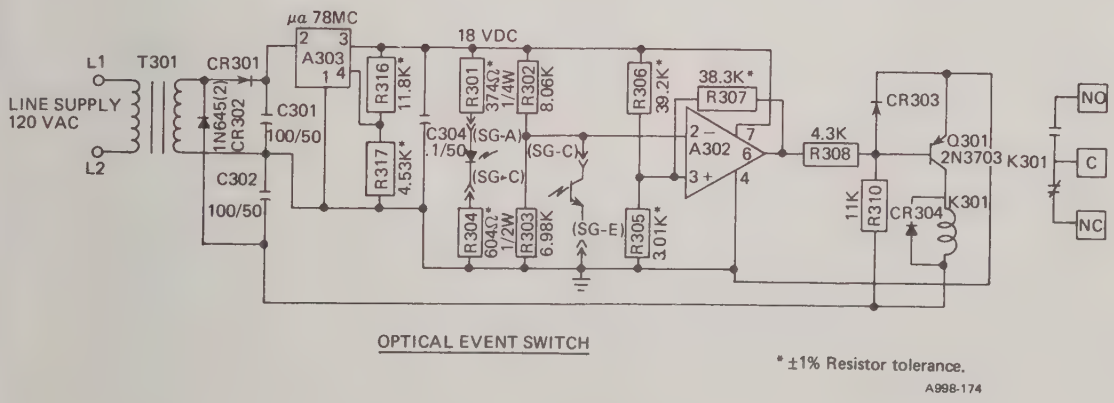


Figure 25 – Optical Event Switch

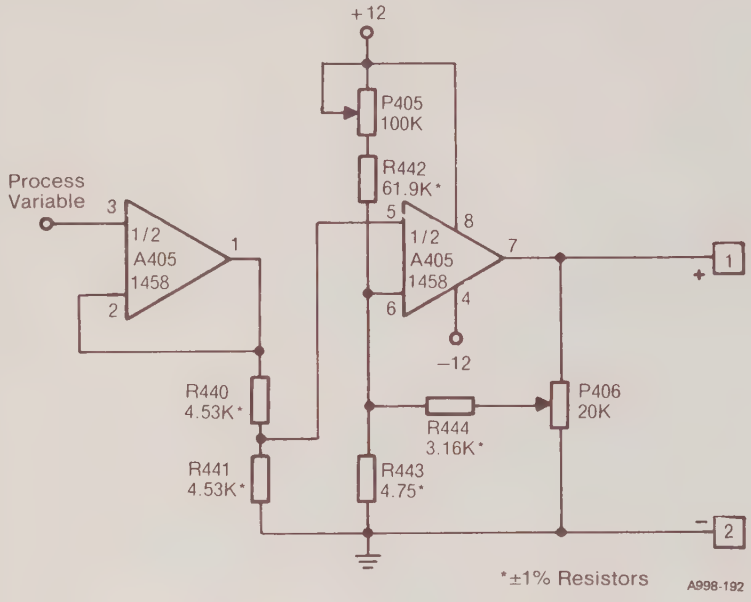


Figure 26 – Process Variable Output

Series AR100
Recorder-Controller and Cam Programmer

Parts List

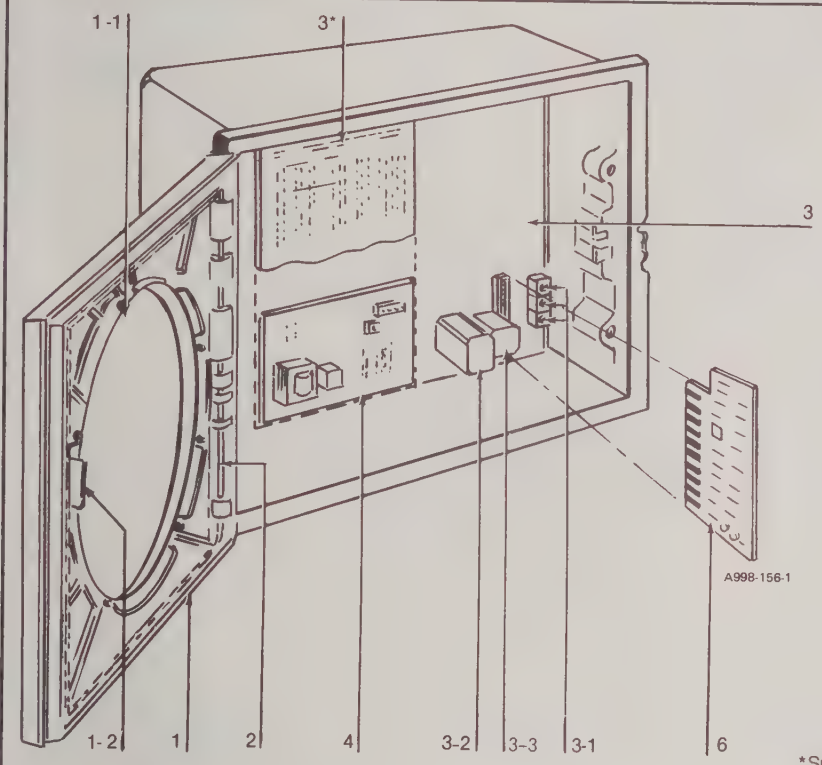


Figure 1 – Case and Door – Chart Plate Removed.

*Supplied only on Two Pen Recorder Controller

FIGURE 1. Case and Door - Chart Plate Removed

Key No.	Part No.	Description	Recommended Spare Parts Per		Quantity Per Unit	
			1	10	Recorder	Prog.
1	24110261-001	Door Assembly (includes window)			1	1
1-1	24001622-001	Window (glass)			1	1
1-2	24400132-001	Door Latch Assembly		1	1	1
	24400125-001	Window Kit (clear acrylic plastic)				
2	24001627-001	Hinge Pin			1	1
3	Refer to Table 1.	Printed Wiring Board Assembly			1 per pen	1
3-1	Refer to Table 2.	Range Resistors			4 per pen	4
3-2	134378	Control Relay for 2-pos. & Time Prop. controllers (plug-in)		1	1 per pen	1
3-2	135300	Control Relay for Limit Control (plug-in)		1	1 per pen	
3-3	24001179-001	Alarm Relay (soldered)			1 per pen	1
4	Refer to Table 3.	Printed Wiring Board Assembly – sequence/event switch and 0-5 Vdc transmission			—	1
5	24400121-001	Panel Mounting Bracket Kit (not illustrated)			1	1
6	24110309-001	Auto Reset Board Assembly (Limit model only)			1 per pen	

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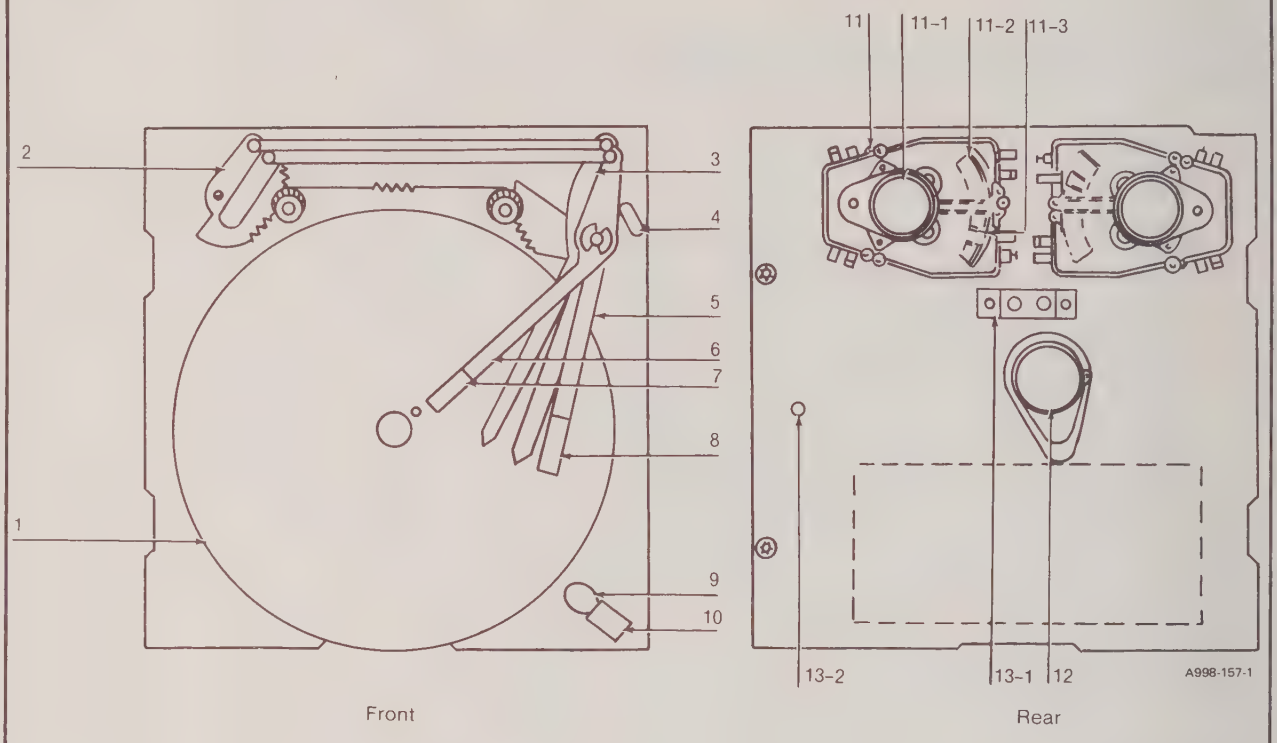

Figure 2 – Chart Plate – Recorder Controller.

FIGURE 2. Chart Plate - Recorder Controller

Key No.	Part No.	Description	Recommended Spare Parts Per		Quantity Per Unit
			1	10	
1	Refer to Table 4.	Chart	1	10	1
2	24110269-001	#2 set point lever/index/link assembly	0	1	1
3	24001610-001	#1 set point index			1
4	24400128-001	Setpoint Mechanical Stop Kit (#1 Pen SP only)			
5	24110260-001	#1 pen arm assembly			1
6	24110270-001	#2 pen arm/linkage			1
7	30735489-002	#1 pen cartridge (red-6 pack)	1	10	1
8	30735489-007	#2 pen cartridge (purple-6 pack)	1	10	1
9	123298	Lamp (#1829)			1
10	24400120-001	Illumination Kit			1
11	24110265-001	Servo assembly-complete with motor-no set point	0	1	
	24110265-002	Servo assembly-complete with motor and set point	0	1	1
11-1	24110274-001	Servo motor assembly			1
11-2	24400122-001	Slidewire			1
11-3	24110264-001	Slidewire wiper arm-set point assy.	0	1	1
	24110263-001	Slidewire wiper arm-pen assembly	0	1	1
12	Refer to Table 6.	Chart drive assembly	0	1	1
13	24200083-001	Lamp and Pushbutton Assembly (includes connector block) not shown	1		
13-1	24001826-001	Lamp	1		
13-2	24110310-001	Manual Reset Button	1		

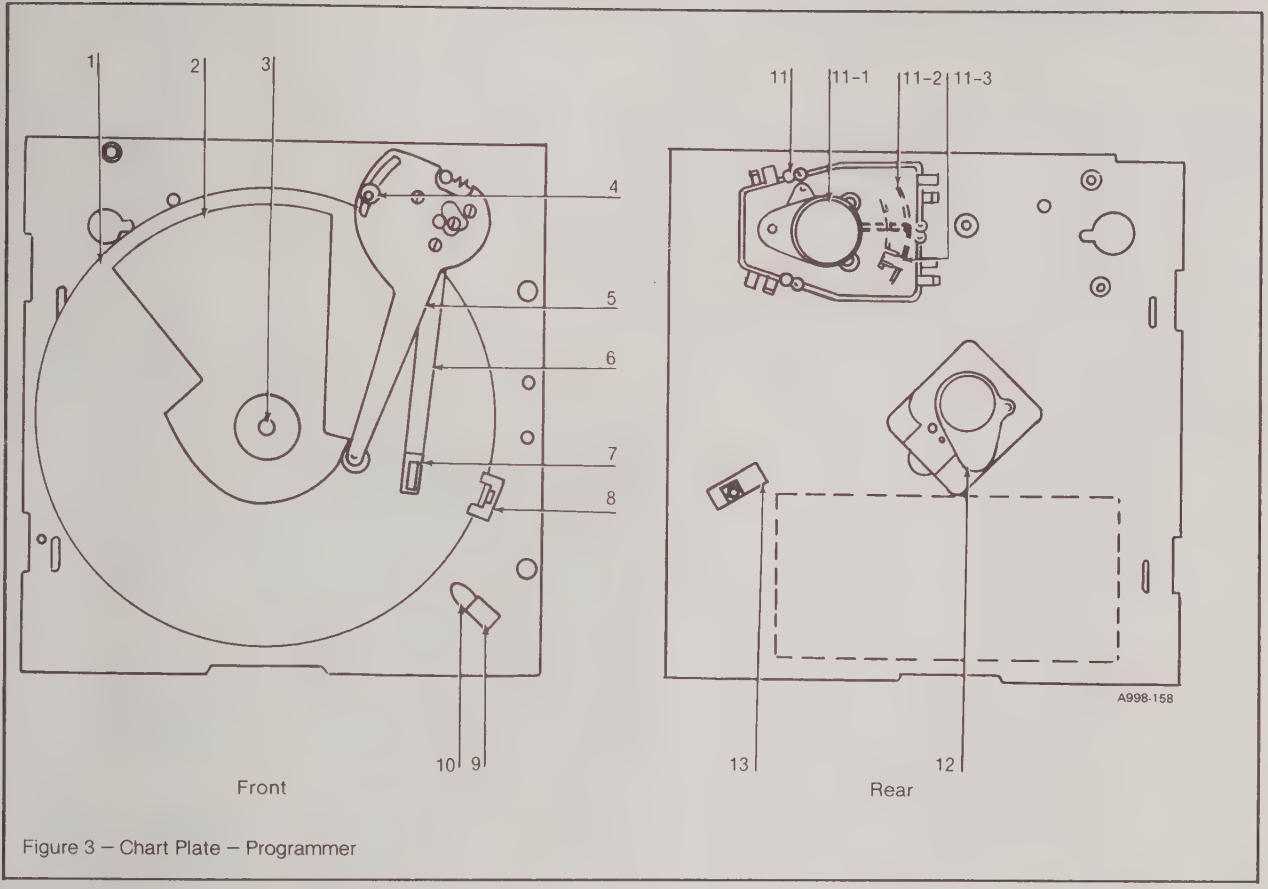

Figure 3 – Chart Plate – Programmer

FIGURE 3. Chart Plate - Programmer

Key No.	Part No.	Description	Recommended Spare Parts Per		Quantity Per Unit
			1	10	
1	Refer to Table 4.	Chart	1	10	1
2	Refer to Table 5.	Cam			1
	24001813-002	Cam layout template (not shown)			1
3	24001805-001	Cam holddown nut			1
4	24001803-001	Follower arm locking nut			1
5	24110301-001	Cam follower arm assembly			1
6	24110260-001	#1 pen arm assembly			1
7	30735489-005	Pen cartridge (red-6 pack)			1
8	24001799-001	Mounting clip-optical sensor			1
9	24400120-001	Illumination kit			1
10	123298	Lamp (# 1829)			1
11	24110265-001	Servo assembly (with motor)	0	1	1
11-1	24110274-001	Servo motor			1
11-2	24400122-001	Slidewire			1
11-3	24110263-001	Slidewire wiper arm			1
12	Refer to Table 6.	Cam and chart drive assembly (motor, hub and support)	0	1	1
13	24110305-001	Optical sensor assembly			1

TABLE 1 – Printed Wiring Board Assemblies (Controller board)

Operation(s)	Part Numbers Per Supply Voltage		
	100V	120V	230V
Record only	24110262-025	24110262-001	24110262-002
Record w/Alarm	24110262-026	24110262-003	24110262-004
Record w/On-Off	24110262-027	24110262-005	24110262-006
Record w/On-Off and Alarm	24110262-028	24110262-007	24110262-008
Record w/Time Prop. (1-mode)	24110252-029	24110262-009	24110262-010
Record w/Time Prop. and Alarm (1-mode)	24110262-030	24110262-011	24110262-012
Record w/Current Prop. (1-mode)	24110262-031	24110262-013	24110262-014
Record w/Current Prop. and Alarm (1-mode)	24110262-032	24110262-015	22110262-016
Record w/Manual Reset Limiter (no separate alarm)		24110308-001	24110308-002
Record w/Time Prop. (3-mode)	24110262-033	24110262-009	24110262-010
Record w/Time Prop. and Alarm (3-mode)	24110262-034	24110262-011	24110262-012
Record w/Current Prop. (3-mode)	24110262-035	24110262-013	24110262-014
Record w/Current Prop. and Alarm (3-mode)	24110262-036	24110262-015	24110262-016

TABLE 2 – Range Change Components

Range	Sensor Type	R1	R2	R3	R4
0-250°F	E	24001651-657 (6.57K)	24001653-649 (649K)	24001652-246 (24.6K)	24001652-530 (53.0K)
−50 to +300°F	J	24001651-787 (7.87K)	24001653-649 (649K)	24001652-348 (34.8K)	24001652-453 (45.3K)
0-300°F	J	24001651-787 (7.87K)	24001653-681 (681K)	24001652-298 (29.8K)	24001652-523 (52.3K)
0-400°F	J	24001651-787 (7.87K)	24001653-576 (576K)	24001652-305 (30.5K)	24001652-388 (38.8K)
0-500°F	J	24001651-787 (7.87K)	24001653-511 (511K)	24001652-316 (31.6K)	24001652-309 (30.9K)
0-600°F	J	24001651-787 (7.87K)	24001653-453 (453K)	24001652-328 (32.8K)	24001652-255 (25.5K)
0-800°F	J	24001651-787 (7.87K)	24001653-374 (374K)	24001652-357 (35.7K)	24001652-191 (19.1K)
0-1000°F	J	24001651-787 (7.87K)	24001653-365 (365K)	24001652-388 (38.8K)	24001652-152 (15.2K)
0-1200°F	J	24001651-787 (7.87K)	24001653-301 (301K)	24001652-427 (42.7K)	24001652-124 (12.4K)
0-1600°F	J	24001651-787 (7.87K)	24001653-215 (215K)	24001652-556 (55.6K)	24001651-898 (8.98K)
50 to 650°F	J	24001651-787 (7.87K)	24001653-442 (442K)	24001652-287 (28.7K)	24001652-252 (25.2K)
50 to 1400°F	J	24001651-787 (7.87K)	24001653-255 (255K)	24001652-388 (38.8K)	24001652-109 (10.9K)
95 to 455°F	J	24001651-787 (7.87K)	24001653-576 (576K)	24001652-240 (24.0K)	24001652-422 (42.2K)
−45 to +150°C	J	24001651-787 (7.87K)	24001653-649 (649K)	24001652-348 (34.8K)	24001652-453 (45.3K)
−18 to +425°C	J	24001651-787 (7.87K)	24001653-374 (374K)	24001652-357 (35.7K)	24001652-191 (19.1K)
0-150°C	J	24001651-787 (7.87K)	24001653-698 (698K)	24001652-271 (27.1K)	24001652-576 (57.6K)
0-250°C	J	24001651-787 (7.87K)	24001653-536 (536K)	24001652-287 (28.7K)	24001652-340 (34.0K)
0-300°C	J	24001651-787 (7.87K)	24001653-475 (475K)	24001652-294 (29.4K)	24001652-284 (28.4K)
0-400°C	J	24001651-787 (7.87K)	24001653-392 (392K)	24001652-312 (31.2K)	24001652-210 (21.0K)
10 to 340°C	J	24001651-787 (7.87K)	24001653-442 (442K)	24001652-287 (28.7K)	24001652-255 (25.5K)
10 to 760°C	J	24001651-787 (7.87K)	24001653-255 (255K)	24001652-388 (38.8K)	24001652-109 (10.9K)
35 to 235°C	J	24001651-787 (7.87K)	24001653-576 (576K)	24001652-240 (24.0K)	24001652-422 (42.2K)

TABLE 2 - Range Change Components (Continued)

Range	Sensor Type	R1	R2	R3	R4
0-400°F	K	24001652-102 (10.2K)	24001653-732 (732K)	24001652-392 (39.2K)	24001652-511 (51.1K)
0-1000°F	K	24001652-102 (10.2K)	24001653-402 (402K)	24001652-493 (49.3K)	24001652-200 (20.0K)
0-1200°F	K	24001652-102 (10.2K)	24001653-402 (402K)	24001652-536 (53.6K)	24001652-167 (16.7K)
0-1600°F	K	24001652-102 (10.2K)	24001653-301 (301K)	24001652-657 (65.7K)	24001652-124 (12.4K)
0-2000°F	K	24001652-102 (10.2K)	24001653-243 (243K)	24001652-845 (84.5K)	24001652-101 (10.1K)
0-2400°F	K	24001652-102 (10.2K	24001653-205 (205K)	24001653-113 (113K)	24001651-856 (8.56K)
+1365 to +1740°F	K	24001652-102 (10.2K)	24001653-464 (464K)	24001651-768 (7.68K)	24001652-549 (54.9K)
−18 to +1320°C	K	24001652-102 (10.2K)	24001653-205 (205K)	24001653-113 (113K)	24001651-856 (8.56K)
0-400°C	K	24001652-102 (10.2K)	24001653-499 (499K)	24001652-397 (39.7K)	24001652-280 (28.0K)
0-600°C	K	24001652-102 (10.2K)	24001653-374 (374K)	24001652-453 (45.3K)	24001652-184 (18.4K)
0-800°C	K	24001652-102 (10.2K)	24001653-294 (294K)	24001652-530 (53.0K)	24001652-138 (13.8K)
0-1000°C	K	24001652-102 (10.2K)	24001653-255 (255K)	24001652-634 (63.4K)	24001652-111 (11.1K)
0-1200°C	K	24001652-102 (10.2K)	24001653-215 (215K)	24001652-777 (77.7K)	24001651-909 (9.09K)
0-2500°F	R	24001652-706 (70.6K)	24001653-619 (619K)	24001654-120 (1.20M)	24001652-294 (29.4K)
30 to 2900°F	R	24001652-706 (70.6K)	24001653-590 (590K)	24001653-723 (723K)	24001652-246 (24.6K)
0-1600°C	R	24001652-706 (70.6K)	24001653-590 (590K)	24001653-723 (723K)	24001652-246 (24.6K)
0-1600°C	S	24001652-706 (70.6K)	24001653-576 (576K)	24001654-115 (1.15M)	24001652-274 (27.4K)
−250 to +150°F	T	24001652-102 (10.2K)	24001653-887 (887K)	24001652-768 (76.8K)	24001652-619 (61.9K)
−130 to +410°F	T	24001652-102 (10.2K)	24001653-619 (619K)	24001652-604 (60.4K)	24001652-357 (35.7K)
−100 to +100°C	T	24001652-102 (10.2K)	24001653-825 (825K)	24001652-569 (56.9K)	24001652-604 (60.4K)
−90 to +210°C	T	24001652-102 (10.2K)	24001653-619 (619K)	24001652-604 (60.4K)	24001652-357 (35.7K)
+75 to −200°C*	T	24001652-102 (10.2K)	24001653-835 (835K)	24001653-102 (102K)	24001652-530 (53.0K)
0-100°F	RTD (Ni-A)	——	24001653-140 (140K)	24001651-530 (5.30K)	24001652-142 (14.2K)
−200 to +100°F	RTD (Pt 100)	——	24001653-332 (332K)	24001652-604 (60.4K)	24001652-280 (28.0K)
−125 to +375°F	RTD (Pt 100)	——	24001653-205 (205K)	24001652-459 (45.9K)	24001652-172 (17.2K)
−35 to +75°F	RTD (Pt 100)	——	24001653-634 (634K)	24001652-294 (29.4K)	24001652-777 (77.7K)
−30 to +170°F	RTD (Pt 100)	——	24001653-499 (499K)	24001652-298 (29.8K)	24001652-427 (42.7K)
−25 to +125°F	RTD (Pt 100)	——	24001653-549 (549K)	24001652-287 (28.7K)	24001652-569 (56.9K)
0-100°F	RTD (Pt 100)	——	24001653-619 (619K)	24001652-267 (26.7K)	24001652-856 (85.6K)
0-200°F	RTD (Pt 100)	——	24001653-523 (523K)	24001652-274 (27.4K)	24001652-432 (43.2K)
0-350°F	RTD (Pt 100)	——	24001653-294 (294K)	24001652-287 (28.7K)	24001652-249 (24.9K)
0-400°F	RTD (Pt 100)	——	24001653-261 (261K)	24001652-291 (29.1K)	24001652-218 (21.8K)
0-600°F	RTD (Pt 100)	——	24001653-174 (174K)	24001652-305 (30.5K)	24001652-194 (19.4K)
20 to 120°F	RTD (Pt 100)	——	24001653-604 (604K)	24001652-255 (25.5K)	24001652-856 (85.6K)
50 to 250°F	RTD (Pt 100)	——	24001653-464 (464K)	24001652-243 (24.3K)	24001652-437 (43.7K)
250 to 450°F	RTD (Pt 100)	——	24001653-402 (402K)	24001652-169 (16.9K)	24001652-453 (45.3K)

*Reverse range requires wiring change to SB connector.

TABLE 2 – Range Change Components (Continued)

Range	Sensor Type	R1	R2	R3	R4
−100 to +200°C	RTD (Pt 100)	——	24001653-191 (191K)	24001652-523 (52.3K)	24001652-160 (16.0K)
−95 to +49°C	RTD (Pt 100)	——	24001653-383 (383K)	24001652-437 (43.7K)	24001652-328 (32.8K)
−85 to +190°C	RTD (Pt 100)	——	24001653-205 (205K)	24001652-448 (44.8K)	24001652-174 (17.4K)
−75 to +260°C	RTD (Pt 100)	——	24001653-174 (174K)	24001652-437 (43.7K)	24001652-145 (14.5K)
−50 to +25°C	RTD (Pt 100)	——	24001653-604 (604K)	24001652-316 (31.6K)	24001652-634 (63.4K)
−35 to +75°C	RTD (Pt 100)	——	24001653-511 (511K)	24001652-298 (29.8K)	24001652-432 (43.2K)
−30 to +70°C	RTD (Pt 100)	——	24001653-523 (523K)	24001652-291 (29.1K)	24001652-475 (47.5K)
−25 to +125°C	RTD (Pt 100)	——	24001653-365 (365K)	24001652-291 (29.1K)	24001652-320 (32.0K)
−18 to +94°C	RTD (Pt 100)	——	24001653-523 (523K)	24001652-274 (27.4K)	24001652-432 (43.2K)
−5 to +50°C	RTD (Pt 100)	——	24001653-604 (604K)	24001652-252 (25.2K)	24001652-866 (86.6K)
0 to −100°C*	RTD (Pt 100)	——	24001653-549 (549K)	24001652-232 (23.2K)	24001652-464 (46.4K)
0-100°C	RTD (Pt 100)	——	24001653-499 (499K)	24001652-252 (25.2K)	24001652-481 (48.1K)
0-200°C	RTD (Pt 100)	——	24001653-287 (287K)	24001652-264 (26.4K)	24001652-246 (24.6K)
0-400°C	RTD (Pt 100)	——	24001653-150 (150K)	24001652-291 (29.1K)	24001652-126 (12.6K)
+49 to −95°C*	RTD (Pt 100)	——	24001653-383 (383K)	24001652-191 (19.1K)	24001652-328 (32.8K)
+50 to −85°C*	RTD (Pt 100)	——	24001653-412 (412K)	24001652-191 (19.1K)	24001652-348 (34.8K)
70 to 140°C	RTD (Pt 100)	——	24001653-499 (499K)	24001652-193 (19.3K)	24001652-698 (69.8K)
+120 to −140°F*	RTD (Pt 100)	——	24001653-383 (383K)	24001652-191 (19.1K)	24001652-324 (32.4K)
−100 to +100°C	DIN RTD (Pt 100)	——	24001653-287 (287K)	24001652-470 (47.0K)	24001652-240 (24.0K)
−40 to +60°C	DIN RTD (Pt 100)	——	24001653-536 (536K)	24001652-301 (30.1K)	24001652-481 (48.1K)
−10 to +60°C	DIN RTD (Pt 100)	——	24001653-576 (576K)	24001652-258 (25.8K)	24001652-698 (69.8K)
0-100°C	DIN RTD (Pt 100)	——	24001653-499 (499K)	24001652-252 (25.2K)	24001652-487 (48.7K)
0-200°C	DIN RTD (Pt 100)	——	24001653-294 (294K)	24001652-264 (26.4K)	24001652-294 (24.9K)
0-250°C	DIN RTD (Pt 100)	——	24001653-237 (237K)	24001652-271 (27.1K)	24001652-200 (20.0K)
0-400°C	DIN RTD (Pt 100)	——	24001653-154 (154K)	24001652-287 (28.7K)	24001652-129 (12.9K)
0-50°F	RTD (Pt 200)	——	24001653-412 (412K)	24001652-132 (13.2K)	24001652-856 (85.6K)
0-200°F	RTD (Pt 200)	——	24001653-255 (555K)	24001652-137 (13.7K)	24001652-215 (21.5K)
−100 to +200°C	RTD (Pt 200)	——	24001652-953 (95.3K)	24001652-258 (25.8K)	24001651-796 (7.96K)
−76 to +100°C	RTD (Pt 200)	——	24001653-162 (162K)	24001652-196 (19.6K)	24001652-135 (13.5K)
−75 to +180°C	RTD (Pt 200)	——	24001653-110 (110K)	24001652-205 (20.5K)	24001651-942 (9.42K)
0-50°C	RTD (Pt 200)	——	24001653-340 (340K)	24001652-123 (12.3K)	24001652-481 (48.1K)
50 to 150°F	RTD (Pt 500)	——	24001653-274 (274K)	24001651-953 (9.53K)	24001652-348 (34.8K)

*Reverse range requires wiring change to S8 connector.

TABLE 2 – Range Change Components (Continued)

Range	Sensor Type	R1	R2	R3	R4
0-50°F	Δ RTD (Pt 200)	——	24001653-332 (332K)	24001653-203 (203K)	24001652-149 (14.9K)
63 to 0°F	Δ RTD (Pt 200)	——	24001653-140 (140K)	24001652-154 (15.4K)	24001652-118 (11.8K)
35 to 0°C	Δ RTD (Pt 200)	——	24001653-140 (140K)	24001652-154 (15.4K)	24001652-118 (11.8K)
20 to 0°F	Δ RTD (Pt 500)	——	24001653-365 (365K)	24001652-213 (21.3K)	24001652-156 (15.6K)
2 to 98%	RH (Q457B)	——	24001653-113 (113K)	24001652-732 (73.2K)	24001651-909 (9.09K)
0-100[a]	1000 Ω slidewire	24001651-732 (7.32K)	24001653-243 (243K)	24001652-221 (22.1K)	24001652-102 (10.2K)
0-10[a]	mV dc	——	24001653-866 (866K)	24001653-517 (517K)	24001652-464 (46.4K)
0-25	mV dc	——	24001653-422 (422K)	24001653-205 (205K)	24001652-184 (18.4K)
0-30	mV dc	——	24001653-365 (365K)	24001653-172 (172K)	24001652-154 (15.4K)
0-100	mV dc	——	24001654-124 (1.24M)	24001654-104 (1.04M)	24001652-931 (93.1K)
0-200[a]	mV dc	——	24001653-866 (866K)	24001653-517 (517K)	24001652-464 (46.4K)
0-500[a]	mV dc	——	24001653-866 (866K)	24001653-517 (517K)	24001652-459 (45.9K)
15-25	mV dc	——	24001653-590 (590K)	24001652-218 (21.8K)	24001652-464 (46.4K)
25-0*	mV dc	——	24001653-422 (422K)	24001653-205 (205K)	24001652-184 (18.4K)
50-0*	mV dc	——	24001653-221 (221K)	24001653-102 (102K)	24001651-920 (9.20K)
0-10[a]	mA dc	——	24001653-442 (442K)	24001653-208 (208K)	24001652-184 (18.4K)
4-20[a]	mA dc	——	24001653-274 (274K)	24001652-556 (55.6K)	24001652-115 (11.5K)
4-22.29[a]	mA dc	——	24001653-221 (221K)	24001652-642 (64.2K)	24001652-101 (10.1K)
0-1[a]	Vdc	——	24001654-124 (1.24M)	24001654-104 (1.04M)	24001652-931 (93.1K)
0-5[a]	Vdc	——	24001653-442 (442K)	24001653-208 (208K)	24001652-187 (18.7K)
0-10	Vdc	——	24001653-221 (221K)	24001653-104 (104K)	24001651-931 (9.31K)
1-5[a]	Vdc	——	24001653-464 (464K)	24001653-113 (113K)	24001652-232 (23.2K)
0-14[a]	pH[c]	——	24001653-274 (274K)	24001652-556 (55.6K)	24001652-115 (11.5K)
0-120[a]	c	——	24001653-274 (274K)	24001652-556 (55.6K)	24001652-115 (11.5K)
0-350[a]	c	——	24001653-274 (274K)	24001652-556 (55.6K)	24001652-115 (11.5K)
0-100[b]	c	——	24001653-274 (274K)	24001652-556 (55.6K)	24001652-115 (11.5K)
0-100[b]	d	——	24001653-464 (464K)	24001653-113 (113K)	24001652-232 (23.2K)

[a](linear or evenly-spaced chart divisions) [c](4 to 20 mA dc)
[b](square root chart divisions) [d](1 to 5 Vdc)
*Reverse range requires wiring change to S_B connector.

TABLE 3 – Optional Accessory Printed Wiring Boards (Event Switching, Program Output)

Operation(s)	Part Numbers per Supply Voltage 100V	120V	230V
Sequence/Event switching and 0-5 Vdc remote set point	24110306-006	24110306-001	24110306-004
Sequence/Event switching only	24110306-007	24110306-002	24110306-005
0-5 Vdc remote set point only	24110306-003	24110306-003	24110306-003
Auto reset on startup and power interrupt for Manual Reset Limit Control		24110309-001	24110309-001

TABLE 4 - Charts

Range	Chart Numbers 1 Day	7 Day
Sensor Type J		
-50 to +300°F	24001660-019	24001661-019
0 to 300°F	24001660-002	24001661-002
0 to 400°F	24001660-012	24001661-006
0 to 500°F	24001660-013	24001661-007
0 to 600°F	24001660-003	24001661-008
0 to 800°F	24001660-014	24001661-009
0 to 1000°F	24001660-015	24001661-010
0 to 1200°F	24001660-004	24001661-011
0 to 1600°F	24001660-018	24001661-018
50 to 650°F	24001660-056	24001661-056
50 to 1400°F	24001660-029	24001661-029
-45 to +150°C	24001660-027	24001661-027
-18 to +425°C	24001660-028	24001661-028
0 to 150°C	24001660-070	24001661-070
0 to 250°C	24001660-024	24001661-024
0 to 300°C	24001660-062	24001661-062
0 to 400°C	24001660-063	24001661-063
10 to 340°C	24001660-057	24001661-057
10 to 760°C	24001660-030	24001661-030
Sensor Type K		
0 to 400°F	24001660-053	24001661-053
0 to 1000°F	24001660-007	24001661-016
0 to 1200°F	24001660-006	24001661-012
0 to 1600°F	24001660-016	24001661-013
0 to 2000°F	24001660-005	24001661-014
0 to 2400°F	24001660-009	24001661-015
-18 to +1320°C	24001660-031	24001661-031
0 to 200°C	24001660-086	——
0 to 400°C	24001660-064	24001661-064
0 to 600°C	24001660-059	24001661-059
0 to 800°C	24001660-060	24001661-060
0 to 1000°C	24001660-049	24001661-049
0 to 1200°C	24001660-065	——
Sensor Type R		
0 to 2500°F	24001660-025	24001661-025
30 to 2900°F	24001660-032	24001661-032
0 to 1600°C	24001660-017	24001661-017
Sensor Type S		
0 to 1600°C	24001660-066	——
Sensor Type T		
-250 to +150°F	24001660-042	24001661-042
-130 to +410°F	24001660-033	24001661-033
-100 to +100°C	24001660-069	24001661-069
-90 to +210°C	24001660-034	24001661-034
+75 to -200°C	——	24001661-058

Range	Chart Numbers 1 Day	7 Day
Linear (or RTD)		
-200 to +100 (°F)	24001660-044	24001661-044
-125 to +375 (°F)	24001660-020	24001661-020
-100 to +100 (°C)	24001660-080	24001661-080
-100 to +200 (°C)	24001660-021	34001661-021
-85 to +190 (°C)	24001660-047	——
-75 to +260 (°C)	24001660-055	24001661-055
-50 to +25 (°C)	——	24001661-048
-40 to +60 (°C)	24001660-067	24001661-067
-35 to +75	24001660-023	24001661-023
-30 to +170 (°F)	24001660-087	24001661-087
-25 to +125	24001660-045	24001661-045
-18 to +94	24001660-035	24001661-035
-5 to +50	24001660-022	24001661-022
0 to -100 (°C)	——	24001661-084
0 to 5	24001660-072	——
0 to 5 (%)	24001660-074	24001661-074
0 to 10	24001660-076	——
0 to 14	24001660-036	24001661-036
0 to 14 (pH)	24001660-073	——
0 to 15	——	24001661-085
0 to 20	——	24001661-071
0 to 40	——	24001661-041
0 to 45	24001660-072	——
0 to 50	——	24001661-051
0 to 70	——	24001661-075
0 to 100	24001660-001	24001661-001
0 to 120	24001660-054	——
0 to 200	24001660-010	24001661-004
0 to 250 (°C)	24001660-068	——
0 to 350	——	24001661-050
0 to 350	24001660-037	24001661-037
0 to 400	24001660-011	24001661-005
0 to 400 (°C)	24001660-081	24001661-081
0 to 600	24001660-052	——
20 to 120	24001660-039	24001661-039
+49 to -95 (°C)	——	24001661-083
50 to -85 (°C)	——	24001661-046
50 to 250	24001660-008	24001661-003
70 to 140	24001660-038	24001661-038
+120 to -140 (°F)	24001660-082	——
square root		
0-100	24001660-043	24001661-043

TABLE 4 – Charts (continued)

Range	Chart Numbers 1 Day	7 Day
Dual Range		
-100 to +200 Linear or RTD	24001660-600	——
35 to 0 Linear or RTD		
0 to 100 Linear or RTD	24001660-601	24001661-601
-30 to +70 Linear or RTD		
0 to 200 Linear or RTD	24001660-602	24001661-602
63 to 0 Linear or RTD		
-18 to +94 Linear or RTD	24001660-603	24001661-603
35 to 0 Linear or RTD		
0 to 600°F, Type J	24001660-604	——
0 to 2400°F, Type K		
0 to 200 Linear or RTD	24001660-605	——
0 to 50 Linear or RTD		
0 to 50 Linear or RTD	24001660-606	24001661-606
0 to 100 Linear (RH, Q457B)		
-76 to +100 RTD	24001660-607	——
35 to 0 Linear or RTD		
-75 to +180 RTD	24001660-608	——
35 to 0 Linear or RTD		
50 to 150 Linear or RTD	24001660-609	——
20 to 0 Linear or RTD		
0 to 600 (°F) Type J T/C	24001660-611	——
0 to 100 Linear or RTD		
1 to 10 Logarithmic Base 10	24001660-613	24001661-613
0 to 2 Linear		
0 to 250 (°F) Type E T/C	24001660-614	24001661-614
0 to 10 Square Root		
95 to 455°F Type J Thermocouple	24001660-026	24001661-026
35 to 235°C Type J Thermocouple		
Special Range		
Machine Uptime/Downtime (#1)	24001829-001	——
Machine Uptime/Downtime (#2)		

TABLE 5 – Cams

Cam No.	Range
24001814-002	without printing
24001814-003	0-100, Linear, 24 hour
24001814-004	0-100, Linear, 7 day

TABLE 6 – Chart (Cam) Drive Assembly

Time	Part No. 60 Hz	50 Hz
All Models (except Cam Programmer)		
24 hr (1 day)	24110273-001	24110273-003
168 hr (7 day)	24110273-002	24110273-004
Cam Programmer Only		
1 hr	24110302-001	24110302-007
4 hr	24110302-002	24110302-008
8 hr	24110302-003	24110302-009
24 hr (1 day)	24110302-004	24110302-010
72 hr (3 days)	24110302-005	24110302-011
168 hr (7 days)	24110302-006	24110302-012

Honeywell

Series AR 100 Recorder-Controller

Model Selection Guide

Specification:
44-01-03-01

Instructions

- Select the desired number of pens. The arrow marks the column in which the selections are to be made.
- Make one selection from each table. A dot (•) denotes unrestricted availability. A letter (example **c**) denotes restricted availability. Restrictions follow Table VI, with squares (■) below the letter identifying the limitations.
- A complete Model Number must contain the designated quantity of digits or letters in each table.

I	II	III	IV	V	VI
— —	—	—		— —	— — —

	Selection	Availability	
Single Pen		↓	↓
Two Pen			

Table I Pen #1 Control Form

	Selection		
Non-control (Recorder Only)	AR1	•	•
On/Off or Hi/Lo (Two Position)	AR2	•	•
Time Proportioning (Single Mode, Manual Reset)	AR3	•	•
Current Proportioning (Single Mode, Manual Reset)	AR4	•	•
Manual Reset Limit	AR6	•	•
Three Mode Time Proportioning	AR7	•	•
Three Mode Current Proportioning	AR8	•	•

Table II Pen #2 Control Form

	Selection		
Single Pen Only	5	•	
Non-Control (Recorder Only)	1		•
On/Off or Hi/Lo (Two Position)	2		•
Time Proportioning (Single Mode, Manual Reset)	3		•
Current Proportioning (Single Mode, Manual Reset)	4		•
Manual Reset Limit	6		•
Three Mode Time Proportioning	7		•
Three Mode Current Proportioning	8		•

Table III Chart Drive

Voltage and Frequency	Time per Revolution			
120 Vac, 60 Hertz	24 Hours	A	q	q
	7 Days	B	q	q
230 Vac, 50 Hertz	24 Hours	C	q	q
	7 Days	D	q	q
120 Vac, 50 Hertz	24 Hours	E	q	q
	7 Days	F	q	q
100 Vac, 50 Hertz	24 Hours	G	q	q
	7 Days	H	q	q
100 Vac, 60 Hertz	24 Hours	J	q	q
	7 Days	K	q	q

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Table IV Sensor and Alarm

Number of Pens	Thermocouple Assembly	Alarm (SPDT)	Selection	Availability: Two Pen	Availability: Single Pen
1	Furnished	With	A	p	
		Without	B	g	
	Not Furnished	With	C	t	
		Without	D	•	
2	Furnished	On Both Pens	E		p
		On Pen #1 Only	F		p
		On Pen #2 Only	G		p
		Without	H		g
	Not Furnished	On Both Pens	J		t
		On Pen #1 Only	K		t
		On Pen #2 Only	L		t
		Without	M		•

Table V Pen #2 Actuation & Range

Pen #2 Range and Actuation	Number of Calibrations on Chart	Selection	Availability: Two Pen	Availability: Single Pen
Single Pen Only	One	N2	•	
Same as Pen #1	One	S1		•
Not same as Pen #1	Two	S2		k
4–20 Milliamperes	One or Two	A1		c
1 to 5 Volts dc	One or Two	A2		c
0 to 5 Volts dc	One or Two	A3		c
5 to 95% RH, Q457B	One or Two	A4		m
1,000 ohm Slidewire, Pressure Transducer	One or Two	A5		n
0 to 500 mV	One or Two	A6		c
0 to 10 mV	One or Two	A7		c
0 to 10 Vdc	One or Two	A8		c

Table VI Pen #1 and Dual Range Actuation

Actuation	Type	Range and Chart Calibration °Fahrenheit	Range and Chart Calibration °Celsius	Chart No. 7 Day 24001661-□□□	Chart No. 24 Hr. 24001660-□□□	Selection	Availability Two Pen	Availability Single Pen
Thermo-couple	J	−50° to +300°F	.....	019	019	**114**	•	•
		.....	−45° to +150°C	027	027	**118**	•	•
		.....	0° to +150°C	070	070	**141**	•	•
		0° to +300°F	.....	002	002	**100**	•	•
		0° to 400°F	.....	012	006	**101**	•	•
		+95° to +455°F	+35° to +235°C	026	026	**117**	•	•
		.....	0° to +250°C	024	024	**115**	•	•
		0° to +500°F	.....	013	007	**102**	•	•
		.....	0° to +300°C	062	062	**134**	•	•
		0° to +600°F	.....	003	008	**103**	•	•
		+50° to +650°F	.....	056	056	**129**	•	•
		.....	+10° to +340°C	057	057	**130**	•	•
		.....	0° to 400°C	063	N.A.	**135**	•	•
		.....	−18 to +425°C	028	028	**119**	•	•
		0° to +800°F	.....	014	009	**104**	•	•
		0° to +1000°F	.....	015	010	**105**	•	•
		0° to +1200°F	.....	004	011	**106**	•	•
		+50 to +1400°F	.....	029	029	**120**	•	•
		.....	+10° to +760°C	030	030	**121**	•	•
		0° to +1600°F	.....	118	018	**113**	•	•
	K	0° to +400°F	.....	053	053	**128**	•	•
		.....	0° to 400°C	064	064	**136**	•	•
		0° to +1000°F	.....	007	016	**111**	•	•
		.....	0° to +600°C	059	059	**132**	•	•
		0° to +1200°F	.....	006	012	**107**	•	•
		.....	0° to +800°C	060	060	**133**	•	•
		0° to +1600°F	.....	016	013	**108**	•	•
		.....	0° to +1000°C	049	049	**127**	•	•
		0° to +2000°F	.....	005	014	**109**	•	•
		.....	0° to +1200°C	065	N.A.	**137**	•	•
		0° to +2400°F	.....	009	015	**110**	•	•
		.....	−18° to +1320°C	031	031	**122**	•	•
	R	0° to +2500°F	.....	025	025	**116**	•	•
		+30° to +2900°F	.....	032	032	**123**	•	•
		.....	0° to +1600°C	017	017	**112**	•	•
		.....	+800° to +1600°C	088	N.A.	**144**	•	•
	S	.....	0° to +1600°C	066	N.A.	**138**	•	•
	T	−250° to +150°F	.....	042	042	**126**	•	•
		.....	+75° to −200°C	N.A.	058	**131**	•	•
		.....	−100° to +100°C	069	069	**140**	•	•
		−130° to 410°F	.....	033	033	**124**	•	•
		.....	−90° to +210°C	034	034	**125**	•	•

Table VI Continued

Actuation	Type	Range and Chart Calibration °Fahrenheit	Range and Chart Calibration °Celsius	Chart No. 7 Day 24001661-□□□	Chart No. 24 Hr. 24001660-□□□	Selection	Availability: Two Pen	Availability: Single Pen
RTD	Pt100Ω	.....	0° to −100°C	N.A.	084	**094**	•	•
		−35° to +75°F	.....	023	023	**060**	•	•
		.....	−50° to +25°C	N.A.	048	**076**	•	•
		−200° to +100°F	.....	044	044	**070**	•	•
		0° to +100°F	.....	001	001	**050**	•	•
		+20° to +120°F	.....	039	039	**068**	•	•
		.....	−100° to +50°C	091	N.A.	**098**	•	•
		.....	+50° to −85°C	N.A.	046	**074**	•	•
		.....	+49° to −95°C	N.A.	083	**092**	•	•
		+120° to −140°F	.....	082	N.A.	**091**	•	•
		.....	−50° to +50°C	092	N.A.	**099**	•	•
		.....	−5° to +50°C	022	022	**058**	•	•
		−25° to +125°F	.....	045	045	**077**	•	•
		.....	−30° to +70°C	601	601	**062**	•	•
		.....	−35° to +75°C	023	023	**059**	•	•
		−30° to +170°F	.....	087	087	**096**	•	•
		0° to 200°F	.....	010	004	**051**	•	•
		.....	−18° to +94°C	035	035	**064**	•	•
		.....	0° to +100°C	001	001	**055**	•	•
		+50° to +250°F	.....	008	003	**052**	•	•
		.....	−25° to +125°C	045	045	**073**	•	•
		.....	+70° to +140°C	038	038	**067**	•	•
		.....	0° to +150°C	090	N.A.	**097**	•	•
		0° to +350°F	.....	037	037	**085**	•	•
		−125° to +375°F	.....	020	020	**057**	•	•
		.....	−85° to +190°C	047	N.A.	**075**	•	•
		.....	−100° to +200°C	021	021	**056**	•	•
		.....	0° to +200°C	010	004	**069**	•	•
		0° to 400°F	.....	011	005	**053**	•	•
		.....	−75° to +260°C	055	055	**079**	•	•
		0° to 600°F	.....	052	N.A.	**078**	•	•
		.....	0° to 400°C	011	005	**061**	•	•
	Pt100Ω DIN	.....	−40° to +60°C	067	067	**081**	•	•
		.....	−100° to +100°C	080	080	**089**	•	•
		.....	0° to 100°C	001	001	**083**	•	•
		.....	0° to +200°C	010	004	**084**	•	•
		.....	0° to +250°C	068	N.A.	**082**	•	•
		.....	0° to +400°C	081	081	**090**	•	•
	Pt200Ω	0° to 50°F	.....	N.A.	051	**040**	•	•
	ΔPt200Ω (95°F ref.)	0° to 50°F	.....	N.A.	051	**087**	•	•
	A Bulb	0° to 100°F	.....	001	001	**086**	•	•

Table VI Continued

Actuation	Type	Range	Chart Calibration	Chart No. 7 Day 24001661-□□□	Chart No. 24 Hr. 24001660-□□□	Two Pen Single Pen Selection	Availability	
RTD	Pt500Ω ΔPt500	#1 Pen +50° to +150°F #2 Pen 20° to 0°F ΔT	50 to 150 20 to 0	609	N.A.	**609**		s
	Pt200Ω ΔPt200Ω	#1 Pen 0° to +200°F #2 Pen 0° to +50°F,ΔT	0 to 200 0 to 50	605	N.A.	**605**		s
	Pt100Ω ΔPt200Ω	#1 Pen 0° to +200°F #2 Pen 63° to 0°F, ΔT	0 to 200 63 to 0	602	602	**602**		s
	Pt100 Pt100	#1 Pen 0° to +200°F #2 Pen 0° to +100°F	0 to 200	010	004	**612**		s
	Pt100 DIN Pt100 DIN	#1 Pen +14° to +122°F #2 Pen +104° to +212°F	14 to 122 104 to 212	619	N.A.	**619**		•
	Pt100 DIN Pt100 DIN	#1 Pen −10° to +50°C #2 Pen +40° to +100°C	−10 to +50 +40 to +100	618	N.A.	**618**		•
	Pt100Ω ΔPt200Ω	#1 Pen −18° to +94°C #2 Pen 35° to 0°C, ΔT	−18 to +94 63 to 0	603	603	**603**		s
	Pt200Ω ΔPt200Ω	#1 Pen −76°to +100°C #2 Pen 35° to 0°C, ΔT	−76 to +100 35 to 0	607	N.A.	**607**		s
	Pt200Ω ΔPt200Ω	#1 Pen −75°to +180°C #2 Pen 35° to 0°C, ΔT	−75 to +180 35 to 0	608	N.A.	**608**		s
	Pt200Ω ΔPt200Ω	#1 Pen−100°to +200°C #2 Pen 35° to 0°C ΔT	−100 to +200 35 to 0	600	N.A.	**600**		s
Actuation	**Type**	**Range and Chart Calibration**						
		°Fahrenheit	**°Celsius**					
TC	J K	#1 Pen 0° to 600°F #2 Pen 0° to 2400°F	0° to 600°F (J) 0° to 2400°F (K)	604	N.A.	**604**		s
	J MV	#1 Pen 0° to 300°F #2 Pen 0 to 10 mV	0° to 300°F (J) 0 to 100 even	617	N.A.	**617**		•
	E MV	#1 Pen 0° to 250°F #2 Pen 0 to +30MV	0° to 250°F (E) 0 to 10 Sq Rt	614	614	**614**		s
	MV K	#1 Pen +50 to 0mV #2 Pen 1365° to 1740°F	0 to 100 even	001	001	**615**		s
Relative Humidity	Pt200Ω Q4578B	#1 Pen 0° to 50°C #2 Pen Table V, #A4	0 to 50 0 to 100	606	606	**606**		s
	Pt100Ω Q457B	#1 Pen −30°to +70°C #2 Pen Table V, #A4	−30 to +70 0 to +100	601	601	**062**	•	•
	Q457B	#1 Pen 5% to 95% RH	0 to +100	001	001	**054**	•	•
	Pt100Ω DIN Q457B	#1 Pen −10° to +60°C #2 Pen Table V, #A4	−10 to +60 0 to +100	N.A.	616	**616**		s
1,000 Ohm	Pressure Transducer	Per transducer selection	0 to +100	001	001	**063**	n	n

Table VI Continued

Actuation	Type	Range	Chart Calibration	Chart No. 7 Day 24001661-□□□	Chart No. 24 Hr. 24001660-□□□	Selection	Availability: Two Pen	Availability: Single Pen
Volt	dc	0 to 1V	0 to 100	001	001	**001**	•	•
		0 to 5V	0 to 100	001	001	**005**	•	•
		0 to 5V	0° to 200°C (K)	086	N.A.	**095**	•	•
		0 to 5V	0 to 300	N.A.	050	**006**	•	•
		0 to 5V	0 to 50	N.A.	051	**007**	•	•
		1 to 5V	0 to 100	001	001	**015**	•	•
		1 to 5V	0 to 100 Sq. Rt.	043	043	**072**	•	•
		0 to 10V	0 to 100	001	001	**008**	•	•
Millivolt	dc	0 to 10	0 to 100	001	001	**010**	•	•
		0 to 200	0 to 100	001	001	**012**	•	•
		0 to 500	0 to 100	001	001	**014**	•	•
		Pen #1 +25 to 0 Pen #2 0 to +25	1 to 10 log 0 to 2 even	613	613	**613**		s
Milliampere	dc	0 to 10	0 to 100	001	001	**021**	•	•
		4 to 20	4 to 9	N.A.	093	**025**	•	•
		4 to 20	0 to 14	036	036	**065**	•	•
		4 to 20	0 to 100	001	001	**020**	•	•
		4 to 20	0 to 100 Sq. Rt.	043	043	**071**	•	•
		4 to 20	0 to 120	054	N.A.	**023**	•	•
		4 to 20	−60 to +215	088	N.A.	**024**	•	•
		4 to 20	0 to 350	037	037	**066**	•	•
		4 to 20	0 to 600	052	N.A.	**022**	•	•
Range and Chart Calibration not listed above—Single Range				New	New		d	d
Dual Range				New	New			d

Restrictions

Restriction Letter	Available Only With: Table	Available Only With: Selection
c	VI	Scale transmitter range so output is compatible with chart graduations of Table VI selection used.
d	VI	Packaged thermocouples types J, K or T
g	VI	6 ___
h	VI	Selection with 0 to 100 chart calibration.
k	V	S2.
m	Check available chart time graduations in Table VI.	
n	Product Mgr. prior approval for new chart or range.	
p	Price add for Pen #2 same as price add for Pen #1 in Table VI.	
q	Robinson–Halpern Co. Model 165 or equal.	
s	**Not Available With**	
t	I, II	Pen(s) having Manual Reset Limit, control selection 6.

Honeywell

Series AR 100 Cam Programmer

Specification
53-01-03-01

Model Selection Guide

Instructions

- Make one selection from each table. A dot (•) denotes unrestricted availability. A letter (example **c**) denotes restricted availability. Restrictions follow Table VI, with squares (■) below the letter identifying the limitations.
- A complete Model Number must contain the designated quantity of digits or letters in each table.

I	II	III	IV	V	VI
___	__	__	__	__	___

		Selection	Availability
	Single Pen		↓
Table I	Cam Programmer	AR5	•
Table II Control Form	Non-Control (Recorder Only)	1	p
	On/Off or Hi/Lo (Two Position)	2	•
	Time Proportioning (Single Mode, Manual Reset)	3	•
	Current Proportioning (Single Mode, Manual Reset)	4	•
	Three Mode Time Proportioning	7	•
	Three Mode Current Proportioning	8	•
Table III Voltage/Freq	**Voltage and Frequency**		
	120 Vac, 60 Hertz	A	•
	50 Hertz	B	•
	230 Vac, 60 Hertz	C	•
	50 Hertz	D	•
	100 Vac, 60 Hertz	E	•
	50 Hertz	F	•

Table IV Sensor and Alarm	**Number of Pens**	**Thermocouple Assembly**	**Alarm (SPDT)**		
	1	Furnished	With	A	g
			Without	B	g
		Not Furnished	With	C	•
			Without	D	•

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Table V Cam, Chart Speed/Cam Function

	Selection	Availability
Cam and Chart Speed		
1 Hour	A __	q
4 Hours	B __	q
8 Hours	C __	q
24 Hours	D __	•
72 Hours	E __	q
7 Days	F __	•
Cam Function		
No Selection	__0	•
Event/Sequence Relay	__1	•
Programmed S.P. Output (0–5 Vdc)	__2	•
Event Relay *and* Programmed S.P. Output	__3	•

Chart No.
7 Day
24001661-□□□
24 Hr.
24001660-□□□

Table VI Pen #1 and Dual Range Actuation

Actuation	Type	Range and Chart Calibration °Fahrenheit	Range and Chart Calibration °Celsius				
Thermocouple	J	−50° to +300	.....	019	019	**114**	•
		.....	−45° to +150°C	027	027	**118**	•
		.....	0° to +150°C	070	070	**141**	•
		0° to +300°F	.....	002	002	**100**	•
		0° to +400°F	.....	012	006	**101**	•
		+95° to +455°F	+35° to +235°C	026	026	**117**	•
		.....	0° to +250°C	024	024	**115**	•
		0° to +500°F	.....	013	007	**102**	•
		.....	0° to +300°C	062	062	**134**	•
		0° to +600°F	.....	003	008	**103**	•
		+50° to +650°F	.....	056	056	**129**	•
		.....	+10° to +340°C	057	057	**130**	•
		.....	0° to 400°C	063	N.A.	**135**	•
		.....	−18° to +425°C	028	028	**119**	•
		0° to +800°F	.....	014	009	**104**	•
		0° to +1000°F	.....	015	010	**105**	•
		0° to +1200°F	.....	004	011	**106**	•
		+50° to +1400°F	.....	029	029	**120**	•
		.....	+10° to +760°C	030	030	**121**	•
		0° to +1600°F	.....	018	018	**113**	•
	K	0° to +400°F	.....	053	053	**128**	•
		.....	0° to 400°C	064	064	**136**	•
		0° to +1000°F	.....	007	016	**111**	•
		.....	0° to +600°C	059	059	**132**	•
		0° to +1200°F	.....	006	012	**107**	•
		.....	0° to +800°C	060	060	**133**	•
		0° to +1600°F	.....	016	013	**108**	•
		.....	0° to +1000°C	049	049	**127**	•
		0° to +2000°F	.....	005	014	**109**	•
		.....	0° to +1200°C	065	N.A.	**137**	•
		0° to +2400°F	.....	009	015	**110**	•
		.....	−18° to +1320°C	031	031	**122**	•

Table VI (Continued)

Actuation	Type	Range and Chart Calibration °Fahrenheit	Range and Chart Calibration °Celsius	Chart No. 7 Day 24001661-□□□	Chart No. 24 Hr. 24001660-□□□	Selection	Availability
Thermocouple	R	0° to +2500°F	.....	025	025	**116**	•
		+30° to +2900°F	.....	032	032	**123**	•
		.....	0° to +1600°C	017	017	**112**	•
		.....	+800° to +1600°C	088	N.A.	**144**	•
	S	.....	0° to +1600°C	066	N.A.	**138**	•
		−250° to +150°F	.....	042	042	**126**	•
	T	.....	+75° to −200°C	N.A.	058	**131**	•
		.....	−100° to +100°C	069	069	**140**	•
		−130° to +410°F	.....	033	033	**124**	•
		.....	−90° to +210°C	034	034	**125**	•
RTD	PT 100Ω	.....	0° to −100°C	N.A.	084	**094**	•
		−35° to +75°F	.....	023	023	**060**	•
		.....	−50° to +25°C	N.A.	048	**076**	•
		−200° to +100°F	.....	044	044	**070**	•
		0° to +100°F	.....	001	001	**050**	•
		+20° to +120°F	.....	N.A.	039	**068**	•
		.....	−100° to +50°C	091	N.A.	**098**	•
		.....	+50° to −85°C	N.A.	046	**074**	•
		.....	+49° to −95°C	N.A.	083	**092**	•
		+120° to −140°F	.....	082	N.A.	**091**	•
		.....	−50° to +50°C	092	N.A.	**099**	•
		.....	−5° to +50°C	022	022	**058**	•
		−25° to +125°F	.....	045	045	**077**	•
		.....	−30° to +70°C	601	601	**062**	•
		.....	−35° to +75°C	023	023	**059**	•
		0° to 200°F	.....	010	004	**051**	•
		.....	−18° to +94°C	035	035	**064**	•
		.....	0° to +100°C	001	001	**055**	•
		+50° to +250°F	.....	008	003	**052**	•
		.....	−25° to +125°C	045	045	**073**	•
		.....	+70° to +140°C	038	038	**067**	•
		.....	0° to +150°C	090	N.A.	**097**	•
		.....	0° to +150°C	090	N.A.	**097**	•
		0° to +350°F	.....	037	037	**085**	•
		−125° to +375°F	.....	020	020	**057**	•
		.....	−85° to +190°C	047	N.A.	**075**	•
		.....	−100° to +200°C	021	021	**056**	•
		.....	0° to +200°C	010	004	**069**	•
		0° to 400°F	.....	011	005	**053**	•
		.....	−75° to +260°C	055	055	**079**	•
		0° to 600°F	.....	052	N.A.	**078**	•
		.....	0° to 400°C	011	005	**061**	•
	PT 100Ω DIN	.....	−40° to +60°C	067	067	**081**	•
		.....	−100° to +100°C	080	080	**089**	•
		.....	0° to 100°C	001	001	**083**	•
		.....	0° to +200°C	010	004	**084**	•
		.....	0° to +250°C	068	N.A.	**082**	•
		.....	0° to +400°C	081	081	**090**	•
	Pt 200Ω	0° to 50°F	.....	N.A.	051	**040**	•
	ΔPt 200Ω (95°F ref.)	0° to 50°F	.....	N.A.	051	**087**	•
	A Bulb	0° to 100°F	.....	001	001	**086**	•

Chart No.
7 Day
24001661-□□□
24 Hr.
24001660-□□□

Table VI (Continued)

Actuation	Type	Range	Chart Calibration			Selection	Availability
Relative Humidity	Q457B	#1 Pen 5% to 95% RH	0 to +100	001	001	**054**	•
1,000 Ohm Slidewire	Pressure Transducer	Per Transducer Selection	0 to +100	001	001	**063**	n
		Range	**Chart Even Calibration**				
Volt	dc	0 to 1V	0 to 100	001	001	**001**	•
		0 to 5V	0 to 100	001	001	**005**	•
		0 to 5V	0° to 200°C (K)	086	N.A.	**095**	•
		0 to 5V	0 to 300	N.A.	050	**006**	•
		0 to 5V	0 to 50	N.A.	051	**007**	•
		1 to 5V	0 to 100	001	001	**015**	•
		1 to 5V	0 to 100 Sq. Rt.	043	043	**072**	•
		0 to 10V	0 to 100	001	001	**008**	•
Millivolt	dc	0 to 10	0 to 100	001	001	**010**	•
		0 to 200	0 to 100	001	001	**012**	•
		0 to 500	0 to 100	001	001	**014**	•
Milliampere	dc	0 to 10	0 to 100	001	001	**021**	•
		4 to 20	5 to 9	N.A.	093	**025**	•
		4 to 20	0 to 14	036	036	**065**	•
		4 to 20	0 to 100	001	001	**020**	•
		4 to 20	0 to 100 Sq. Rt.	043	043	**071**	•
		4 to 20	0 to 120	054	N.A.	**023**	•
		4 to 20	−60 to 215	088	N.A.	**024**	•
		4 to 20	0 to 350	037	037	**066**	•
		4 to 20	0 to 600	052	N.A.	**022**	•
Range and Chart Calibration not listed above – Single Range				New	New		d

Restrictions

Restriction Letter	Available Only With	
d g n p q	Table	Selection
g	VI	Packaged Thermocouples types J, K or T
p	V	1, 2, or 3
d	Product Mgr. prior approval required for new chart or range.	
n	Robison–Halpern Co. Model 165 or equal	
q	Chart time graduations of 24 hours where available in Table VI unless 7 day chart requested.	

HOW TO USE TABLES

On the following pages, Table 1 lists the relative humidity for the difference in wet and dry bulb temperatures in °F; Table 2 gives the same in °C.

Read the air temperature as measured by the dry bulb in the left-hand column of the table. Select the degrees below dry bulb temperature as measured by the wet bulb (top row of figures across table). Read down that column to the figure oppossite dry bulb temperature.

Examples

In Table 1, dry bulb temperature is 110°F. Wet bulb temperature is 10°F lower. Relative humidity is 70%.

In Table 2, dry bulb temperature is 35°C. Wet bulb temperature is 9°C lower. Relative humidity is 49%.

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TABLE 1
Difference Between Wet and Dry Thermometers in Degrees Fahrenheit at a Pressure of 30.0" of Mercury

Air Temp. Dry Bulb Reading Degrees Fahrenheit	Difference Between Wet and Dry Bulb Thermometer in Degrees Fahrenheit.																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
20	85	70	55	40	26	12																						
21	85	71	56	42	28	15	1																					
22	86	71	58	44	31	17	4																					
23	86	72	59	46	33	20	7																					
24	87	73	60	47	35	22	10																					
25	87	74	62	49	37	25	13	1																				
26	87	75	63	51	39	27	16	4																				
27	88	76	64	52	41	29	18	7																				
28	88	76	65	54	43	32	21	10																				
29	88	77	66	55	44	34	23	13	3																			
30	89	78	67	56	46	36	26	16	6																			
31	89	78	68	58	47	37	28	18	8																			
32	89	79	69	59	49	39	30	20	11	2																		
33	90	80	70	60	51	41	32	23	14	5																		
34	90	81	71	62	52	43	34	25	16	8																		
35	91	81	72	63	54	45	36	27	19	10	2																	
36	91	82	73	64	55	46	38	29	21	13	5																	
37	91	83	74	65	57	48	40	31	23	15	7																	
38	91	83	75	66	58	50	42	33	25	17	10	2																
39	92	83	75	67	59	51	43	35	27	20	12	5																
40	92	83	75	68	60	52	45	37	29	22	15	7	0															
41	92	84	76	69	61	54	46	39	31	24	17	10	3															
42	92	85	77	69	62	55	47	40	33	26	19	12	5															
43	92	85	77	70	63	55	48	42	35	28	21	14	8	1														
44	93	85	78	71	63	56	49	43	36	30	23	16	10	4														
45	93	86	78	71	64	57	51	44	38	31	25	18	12	6														
46	93	86	79	72	65	58	52	45	39	32	26	20	14	8	2													
47	93	86	79	72	66	59	53	46	40	34	28	22	16	10	5													
48	93	86	79	73	66	60	54	47	41	35	29	23	18	12	7	1												
49	93	86	80	73	67	61	54	48	42	36	31	25	19	14	9	3												
50	93	87	80	74	67	61	55	49	43	38	32	27	21	16	10	5	0											
51	94	87	81	75	68	62	56	50	45	39	34	28	23	17	12	7	2											
52	94	87	81	75	69	63	57	51	46	40	35	29	24	19	14	9	4											
53	94	87	81	75	69	63	58	52	47	41	36	31	26	20	16	10	6	1										
54	94	88	82	76	70	64	59	53	48	42	37	32	27	22	17	12	8	3										
55	94	88	82	76	70	65	59	54	49	43	38	33	28	23	19	14	9	5	0									
56	94	88	82	76	71	65	60	55	50	44	39	34	30	25	20	16	11	7	2									
57	94	88	82	77	71	66	61	55	50	45	40	35	31	26	22	17	13	8	4									
58	94	88	83	77	72	66	61	56	51	46	41	37	32	27	23	18	14	10	6	1								
59	94	89	83	78	72	67	62	57	52	47	42	38	33	29	24	20	15	11	7	3								
60	94	89	83	78	73	68	63	58	53	48	43	39	34	30	26	21	17	13	9	5	1							
61	94	89	84	78	73	68	63	58	54	49	44	40	35	31	27	22	18	14	10	7	3							
62	94	89	84	79	74	69	64	59	54	50	45	41	36	32	28	24	20	16	12	8	4	1						
63	95	89	84	79	74	69	64	60	55	50	46	42	37	33	29	25	21	17	13	10	6	2						
64	95	90	84	79	74	70	65	60	56	51	47	43	38	34	30	26	22	18	15	11	7	4	0					
65	95	90	85	80	75	70	66	61	56	52	48	44	39	35	31	27	24	20	16	12	9	5	2					
66	95	90	85	80	75	71	66	61	57	53	48	44	40	36	32	29	25	21	17	14	10	7	3	0				
67	95	90	85	80	75	71	66	62	58	53	49	45	41	37	33	30	26	22	19	15	12	8	5	2				
68	95	90	85	80	76	71	67	62	58	54	50	46	42	38	34	31	27	23	20	16	13	10	6	3				
69	95	90	85	81	76	72	67	63	59	55	51	47	43	39	35	32	28	24	21	18	14	11	8	5	1			
70	95	90	86	81	77	72	68	64	59	55	51	48	44	40	36	33	29	25	22	19	15	12	9	6	3			
71	95	90	86	81	77	72	68	64	60	56	52	48	45	41	37	33	30	27	23	20	17	13	10	7	4	1		
72	95	91	86	82	77	73	69	65	61	57	53	49	45	42	38	34	31	28	24	21	18	15	12	9	6	3		
73	95	91	86	82	78	73	69	65	61	57	53	50	46	42	39	35	32	29	25	22	19	16	13	10	7	4	1	
74	95	91	86	82	78	74	69	65	61	58	54	50	47	43	39	36	33	29	26	23	20	17	14	11	8	5	3	
75	96	91	86	82	78	74	70	66	62	58	51	51	47	44	40	37	34	30	27	24	21	18	15	12	9	7	4	1
76	96	91	87	82	78	74	70	66	62	59	55	51	48	44	41	38	34	31	28	25	22	19	16	13	11	8	5	3
77	96	91	87	83	79	74	71	67	63	59	56	52	48	45	42	39	35	32	29	26	23	20	17	14	12	9	6	4
78	96	91	87	83	79	75	71	67	63	60	56	53	48	46	43	39	36	33	30	27	24	21	18	16	13	10	8	5
79	96	91	87	83	79	75	71	68	64	60	57	53	50	48	43	40	37	34	31	28	25	22	19	17	14	11	9	6

NOTE Temperature depressions given in this table strictly apply only when the wet bulb is subjected to a current of air with a velocity of not less than 15 feet per second

TABLE 1 - Continued
Difference Between Wet and Dry Bulb Thermometers in Degrees Fahrenheit at a Pressure of 30.0" of Mercury

| Air Temp. Dry Bulb Reading Degrees Fahrenheit | Difference Between Wet and Dry Bulb Thermometer in Degrees Fahrenheit. | | |

TABLE 1 - Continued
Difference Between Wet and Dry Bulb Thermometers in Degrees Fahrenheit at a Pressure of 30.0" of Mercury

Air Temp. Dry Bulb Reading Degs. F.	Difference Between Wet and Dry Bulb Thermometers in Degrees Fahrenheit																												
	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
102	0																													
104	2	0																												
106	4	2	0																											
108	7	4	2	0																										
110	9	6	4	2																										
112	10	7	5	3	0																									
114	11	8	6	4	1	0																								
116	12	9	7	5	3	1																								
118	12	11	9	7	4	2	0																							
120	14	11	9	7	5	3	1																							
122	15	12	10	8	6	4	2																							
124	16	13	11	9	7	5	2	0																						
126	17	14	12	10	8	6	3	1	0																					
128	18	16	14	12	10	7	4	2	1	0																				
130	19	17	15	13	11	8	6	4	3	2	0																			
132	20	18	16	14	12	9	7	5	4	3	1																			
134	21	19	17	15	13	10	8	6	5	4	2	0																		
136	21	19	18	16	14	11	9	7	6	5	3	1	0																	
138	22	20	19	17	15	12	10	8	7	6	4	2	1																	
140	23	21	19	17	15	13	10	9	8	7	5	3	2	0																
142	24	22	20	18	16	14	12	10	9	8	6	4	3	1	0															
144	24	22	20	19	17	15	13	11	10	8	7	5	4	2	1	0														
146	25	23	21	19	17	15	13	11	10	9	7	6	5	3	2	1														
148	25	23	22	20	18	16	14	12	11	10	8	7	5	4	3	1														
150	26	24	22	21	19	17	15	13	12	11	9	7	6	4	3	2	0													
152	26	24	23	21	19	17	15	13	12	11	9	8	6	5	4	3	1	0												
154	27	25	24	22	20	17	16	14	13	12	10	9	7	6	5	4	2	1												
156	28	26	24	22	20	18	16	14	13	12	11	10	8	7	6	4	2	1	0											
158	28	26	25	23	21	19	17	15	14	13	12	10	9	8	7	5	3	2	1											
160	29	27	26	24	22	20	19	17	16	14	12	10	9	7	6	5	4	3	1	0										
162	29	27	26	25	23	21	20	18	17	15	13	11	10	8	7	6	4	3	2	1										
164	30	28	26	25	23	22	21	19	17	15	13	12	10	9	8	6	5	4	2	1										
166	30	28	27	26	24	23	22	20	18	16	14	12	11	10	9	7	5	4	3	2	1									
168	31	29	28	26	24	23	22	20	18	16	14	13	12	11	10	8	6	5	4	2	1	0								
170	31	29	28	27	25	24	23	21	19	17	15	14	12	11	10	8	7	5	4	3	2	1	0							
172	31	30	29	27	25	24	23	21	19	17	15	14	13	12	10	9	7	6	5	4	3	2	1	0						
174	32	30	29	28	26	25	24	22	20	18	16	15	13	12	11	9	8	6	5	4	3	2	1	1	0					
176	32	30	29	28	26	25	24	22	20	18	16	15	14	12	11	10	9	7	6	5	4	3	2	1	1	0				
178	33	31	30	28	27	26	25	23	21	19	17	16	14	13	12	10	9	7	6	5	4	4	3	2	2	1				
180	33	31	30	28	27	26	25	23	21	19	17	16	14	13	12	11	10	8	7	6	5	4	3	3	2	1				
182	33	32	30	29	28	27	26	24	22	20	18	17	15	14	12	11	10	8	7	6	5	5	4	4	3	2	1	0		
184	34	32	31	29	28	27	26	24	22	20	18	17	15	14	13	12	11	9	8	7	6	5	5	4	3	2	1	1		
186	34	33	31	29	28	27	26	24	22	20	18	17	16	15	13	12	11	9	8	7	6	6	5	4	3	3	2	1	0	
188	35	33	32	30	29	28	27	25	23	21	19	18	16	15	14	13	12	10	9	8	7	6	6	5	4	3	2	2	1	0
190	35	33	32	30	29	28	27	25	23	21	19	18	17	15	14	13	12	10	9	8	7	6	6	5	4	4	3	2	1	0
192	36	34	32	30	29	28	27	26	24	22	20	18	17	16	15	13	12	11	9	8	7	7	6	5	5	4	3	3	2	1
194	36	34	32	31	30	29	28	26	24	22	20	19	17	16	15	14	13	11	10	9	8	7	7	6	6	5	4	3	2	1
196	37	35	33	31	30	29	28	26	24	22	20	19	18	16	15	14	13	12	10	9	8	8	7	6	6	5	4	3	2	2
198	37	35	33	31	30	29	28	27	25	23	21	19	18	16	15	14	13	12	11	10	9	8	8	7	6	6	5	4	3	2
200	38	36	33	32	31	30	29	27	25	23	21	20	18	17	16	15	14	13	11	10	9	9	8	8	7	6	5	4	3	3
202	38	36	34	32	31	30	29	28	26	24	22	20	19	18	17	15	14	13	12	11	10	9	9	8	7	7	6	5	4	3
204	39	36	34	33	31	30	29	28	26	24	22	20	19	18	17	16	15	14	12	11	11	10	9	9	8	7	6	5	4	4
206	39	37	35	33	32	31	30	28	26	24	22	21	20	19	17	16	15	14	13	12	11	10	10	9	8	8	7	6	5	4
208	40	37	35	33	32	31	30	29	27	25	23	21	20	19	18	16	15	14	13	12	11	11	10	9	9	8	7	6	5	5
210	40	38	36	34	32	31	30	29	27	25	23	22	20	19	18	17	16	15	14	13	12	11	11	10	9	9	8	7	6	5
212	41	38	36	34	33	32	31	29	27	25	24	23	21	20	18	17	16	15	14	13	12	12	11	11	10	9	8	7	6	6

NOTE: Temperature depressions given in this table strictly apply only when the wet bulb is subjected to a current of air with a velocity of not less than 15 feet per second.

TABLE 2

Difference Between Wet and Dry Bulb Thermometers in Degrees Centigrade at a Pressure of 760 mm of Mercury.

Air Temp. Dry Bulb Reading Degrees Centigrade	Difference Between Wet and Dry Bulb Thermometers in Degrees Centigrade																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
0	81	64	46	29	13																				
1	82	66	48	33	16																				
2	83	68	50	37	21	7																			
3	84	69	54	40	25	12																			
4	85	70	55	43	27	14																			
5	86	72	58	45	31	18	6																		
6	87	73	60	47	35	23	11																		
7	87	74	62	49	38	26	14																		
8	87	75	63	51	40	28	17	6																	
9	88	76	65	53	42	30	22	12	3																
10	88	77	66	55	43	33	23	14	4																
11	88	77	67	56	46	36	26	17	8																
12	89	78	68	58	48	38	30	21	12	4															
13	89	79	68	58	49	39	32	23	15	7															
14	89	80	70	60	51	41	34	25	18	10															
15	90	80	71	62	53	44	36	28	20	13	4														
16	90	80	71	63	54	45	37	30	23	16	7														
17	90	81	72	63	55	47	39	32	25	18	10	4													
18	90	82	73	65	57	49	42	35	27	20	13	6													
19	91	82	73	65	57	49	42	37	28	22	15	8	2												
20	91	82	74	66	58	51	44	38	30	24	17	11	5												
21	91	83	75	67	60	53	46	39	32	26	19	13	8												
22	92	84	75	68	61	54	47	40	33	28	21	16	11	5											
23	92	84	76	68	62	54	48	41	35	29	23	18	12	6	1										
24	92	85	77	70	63	56	49	43	37	31	26	21	14	9	4										
25	92	85	77	70	63	57	50	44	38	32	27	21	16	11	6	3									
26	92	85	78	70	64	58	52	45	39	34	29	24	18	13	9	5									
27	93	86	79	72	65	59	53	47	41	36	31	26	20	14	10	7	1								
28	93	86	79	72	65	59	53	48	41	37	32	27	21	16	12	9	3								
29	93	86	79	72	66	60	54	49	42	38	34	28	23	18	14	11	6	2							
30	93	86	79	73	67	61	55	50	44	39	35	30	25	20	16	13	8	4							
31	93	86	79	73	67	62	55	50	45	40	35	31	26	22	18	15	10	6	2						
32	93	86	80	73	68	62	56	51	46	41	36	32	28	24	19	17	12	8	4	1					
33	93	86	80	74	68	63	57	52	47	42	37	33	29	25	21	19	14	10	6	3					
34	93	87	80	74	68	63	58	53	48	43	38	34	30	26	22	20	15	11	7	4					
35	93	87	81	74	69	64	58	54	49	44	39	35	31	28	23	21	16	13	8	6	1				
36	93	87	81	75	70	64	58	54	50	45	41	36	31	28	24	22	17	14	9	8	3	1			
37	93	87	81	75	70	65	59	54	50	45	41	37	33	29	25	23	18	15	11	9	6	3			
38	93	87	82	76	70	66	60	55	51	46	42	39	34	30	26	24	20	16	12	10	7	4			
39	94	88	82	76	71	66	61	56	52	47	43	39	34	32	28	25	21	17	14	10	8	6			
40	94	88	82	76	71	67	61	57	52	48	44	40	36	33	29	26	22	19	15	10	9	7			
41	94	88	83	77	72	67	62	57	52	49	44	41	37	34	30	28	23	20	16	14	11	9			
42	94	88	83	77	72	68	63	58	53	49	45	42	38	35	31	29	24	21	18	16	12	10			
43	94	88	83	77	72	68	63	58	54	49	45	42	39	36	32	29	25	22	19	17	13	11			
44	94	88	83	77	73	68	63	59	55	50	46	43	39	36	32	29	25	23	20	18	14	12			
45	95	88	83	78	73	68	64	59	55	51	47	43	39	36	33	29	26	24	21	19	15	13			
46	95	89	84	78	74	69	64	60	56	52	47	44	40	37	34	32	27	25	22	20	16	14			
47	95	89	84	78	74	69	65	60	56	52	48	45	41	38	34	33	28	26	23	20	17	15			
48	95	89	84	79	74	70	65	61	57	53	49	45	42	39	35	34	29	27	24	21	18	16			
49	95	89	84	79	74	70	66	61	57	53	49	46	42	40	36	34	30	28	25	22	19	17			

NOTE: The temperature depressions given in these tables strictly apply when the wet bulb is subject to a current of air with a velocity of not less than 15 ft. per second.

TABLE 2 - Continued

Difference Between Wet and Dry Bulb Thermometers in Degrees Centigrade at a Pressure of 760 mm of Mercury.

Air Temp. Dry Bulb Reading Degrees Centigrade	Difference Between Wet and Dry Bulb Thermometers in Degrees Centigrade																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
50	95	89	85	79	75	70	66	62	58	54	50	47	43	40	37	35	31	29	26	23	20	18			
51	95	89	85	80	75	71	66	62	59	54	50	47	44	41	38	36	32	29	26	24	21	19			
52	95	89	85	80	75	71	67	63	59	55	51	48	45	42	38	37	32	30	26	25	22	20			
53	95	89	85	80	75	71	67	63	60	56	52	49	45	42	38	37	33	31	27	25	23	21			
54	95	89	85	80	76	71	67	63	60	56	52	49	45	42	39	38	34	32	28	25	24	21			
55	95	89	85	80	76	71	68	63	60	56	52	49	46	43	40	38	34	32	29	26	25	22			
56	95	90	85	81	76	72	68	64	60	56	53	50	46	44	40	39	35	32	29	27	25	23			
57	95	90	85	81	76	72	68	64	61	57	53	50	47	44	41	39	35	33	30	28	26	23			
58	95	90	85	81	77	72	69	64	61	57	54	51	47	45	41	40	36	34	30	28	27	24			
59	95	90	86	81	77	73	69	65	62	58	54	51	48	45	42	40	36	34	31	29	27	24			
60	95	90	86	81	77	73	69	65	62	58	54	52	48	46	43	41	37	34	31	29	27	25			
61	95	90	86	82	77	73	69	65	62	58	55	52	49	46	43	41	37	35	32	30	28	26			
62	95	90	86	82	78	73	70	66	62	59	55	53	49	47	44	42	38	36	33	31	29	26			
63	95	90	86	82	78	73	70	66	63	59	56	53	49	47	44	42	38	36	34	31	29	26			
64	95	90	87	82	78	73	70	66	63	59	56	53	50	47	44	42	39	37	34	32	30	27			
65	95	90	87	82	78	74	70	66	63	60	56	53	50	48	45	42	39	37	35	32	30	28			
66	95	90	87	82	78	74	71	67	64	60	57	54	50	48	45	43	40	38	36	33	31	29			
67	96	91	87	83	79	74	71	67	64	60	57	54	51	48	46	44	40	38	36	33	32	29			
68	96	91	87	83	79	74	71	67	65	61	58	55	51	48	46	44	41	39	36	34	32	29			
69	96	91	87	83	79	75	72	67	65	61	58	55	52	49	46	45	41	39	36	34	32	30			
70	96	91	88	83	79	75	72	68	65	61	58	55	52	50	47	45	42	40	37	35	33	30			
71	96	91	88	83	79	75	72	68	65	62	58	56	53	50	47	45	42	40	37	35	33	31			
72	96	91	88	84	80	75	72	69	66	62	59	58	53	51	47	46	43	41	38	36	34	31			
73	96	91	88	84	80	75	72	69	66	62	59	57	53	51	48	47	44	41	38	36	34	32			
74	96	92	88	84	80	76	72	69	66	62	59	57	54	51	48	47	44	42	38	36	34	32			
75	96	92	88	84	80	76	73	69	66	63	59	57	54	51	48	47	44	42	39	37	35	33			
76	96	92	88	84	80	76	73	69	67	63	60	58	54	52	49	47	44	42	39	37	35	33			
77	96	92	88	84	80	76	73	70	67	63	60	58	55	53	49	47	45	43	40	38	36	34			
78	96	92	88	84	81	76	73	70	67	64	60	58	55	53	50	48	45	43	40	38	36	34			
79	96	92	88	84	81	76	74	70	67	64	61	58	55	53	50	48	45	43	41	39	36	34			
80	96	92	89	84	81	77	74	71	68	64	61	59	56	53	50	49	46	44	41	39	37	34			
81	96	92	89	84	81	77	74	71	68	64	61	59	56	54	51	49	46	44	41	39	37	35			
82	96	92	89	84	81	77	74	71	68	65	62	59	56	54	51	50	46	44	41	40	38	35			
83	96	92	89	84	81	77	75	71	68	65	62	59	57	54	51	50	47	45	42	40	38	35			
84	96	92	89	84	81	77	75	71	69	65	62	59	57	55	52	50	47	45	42	40	38	36			
85	96	93	89	84	82	77	75	72	69	65	62	60	57	55	52	50	47	45	42	40	39	36			
86	96	93	89	84	82	78	75	72	69	66	63	60	58	55	52	51	48	45	42	41	39	37			
87	96	93	89	85	82	78	75	72	69	66	63	60	58	55	52	51	48	46	43	41	39	37			
88	96	93	89	85	82	78	75	72	69	66	63	60	58	56	53	51	48	46	43	42	39	37			
89	96	93	89	85	82	78	75	72	69	66	63	60	58	56	53	51	48	46	43	42	40	37			
90	96	93	89	85	82	78	75	72	69	66	63	60	58	56	53	51	48	46	43	42	40	38			
91	96	93	89	85	82	78	75	72	69	66	63	60	58	56	53	52	48	46	44	42	40	38			
92	96	93	89	85	82	78	75	73	70	67	63	60	58	56	53	52	48	47	44	42	40	38			
93	96	93	89	85	82	78	76	73	70	67	63	60	58	56	53	52	48	47	44	43	40	38			
94	96	93	89	85	82	78	76	73	70	67	64	60	58	56	53	52	49	47	44	43	40	38			
95	96	93	89	85	82	78	76	73	70	67	64	60	58	56	53	52	49	47	44	43	41	38			
96	96	93	89	85	82	79	76	73	70	67	64	61	59	56	53	53	49	48	45	43	41	39			
97	96	93	89	85	82	79	76	73	70	67	64	61	59	57	53	53	50	48	45	43	41	39			
98	96	93	89	85	82	79	76	73	70	67	64	61	59	57	54	53	50	48	45	43	41	39			
99	96	93	89	85	82	79	76	73	70	67	64	61	59	57	54	53	50	48	45	43	41	39			
100	96	93	89	85	82	79	76	73	70	67	64	61	59	57	54	53	50	48	45	43	41	39			

NOTE: Temperature depressions given in table strictly apply only when the wetbulb is subject to a current of air with a velocity of not less than 15 feet per second.

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